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THE COST OF QUARRYING RUBBLE AND DIMENSION STONE FOR THE BUFFALO, N. Y., STONE BREAKWATER.*

By Emile Low, M. Am., Soc. C. E.†

The major portion of the rubble stone and all of the capping stone used in the construction of the Buffalo, N. Y., stone breakwater was obtained from the Canadian quarry of Hughes Bros. & Bangs, Contractors. The quarry is situated about 6 miles west of Buffalo, N. Y., at Windmill Point, Ontario, on the north or Canadian shore of Lake Erie. For miles in the vicinity of the quarry, the ground surface is comparatively level, the silicious limestone rock of upper Helderberg age, similar to those exposed in the southernmost limestone quarries at Buffalo, being overlaid by a thin layer of earth, in many places not over a foot in depth. Owing to these topographical features, the quarrying is all done below the ground level, the operations being in the nature of a huge excavation.

At first a narrow channel, about 30 ft. deep was made in order to obtain a working face, after which the stone was quarried in benches, the depth of which was governed by the natural seams in the formation. A typical view of the quarry face is shown by the accompanying engravings. The method of quarrying briefly described was as follows: A row of holes, averaging about 4 ft. apart, was drilled parallel with the face. The distance back was first 6 ft., then 12 ft. and finally 18 ft. The depth of the holes varied with the strata.

A so-called line shot consisted of from 25 to 50 holes, all fired simultaneously by an electric battery. The effect of this shot was to move out bodily about 2 ft., a huge block of stone. This was afterwards cut up into blocks averaging about 6 tons weight or 72 cu. ft. However, many blocks of 10, 12, 15 and 17 tons were blasted out.

Many of the holes of the top course were 12 ft. deep, about 2½ to 3 lbs. of powder was used in each of these holes, an air chamber being used invariably, either at the bottom of the hole, below the powder, or above the same, as the tightness of the seam required.

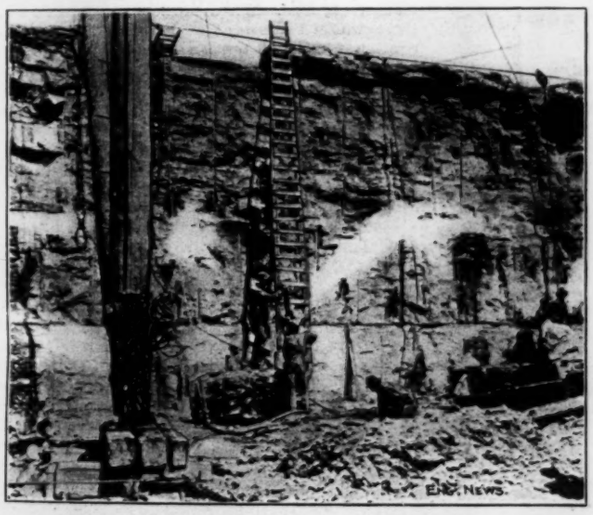
This quarry was opened in the year 1897, and was partially dismantled in December, 1902. The figures of cost, of which this article treats, are of the year 1903, from May to September, inclusive. During this period 56,114.7 tons of rubble and 15,865.8 tons of capping stone, a total of 71,980.5 tons were quarried.

The plant consisted of the following:

2 A Sergeant machine drills.
9 C " " "
3 F " " "
9 derricks, 8 at quarry, 1 at loading dock.
4 50-HP. boilers for furnishing steam used by quarry derricks.
2 skeleton hoists for operating quarry derricks.
1 hoist with boiler for operating incline plane.
1 hoist with boiler for operating derrick at dock.
1 boiler for steam pumps.
2 steam pumps for keeping quarry dry.
1 narrow gage (3 ft.) locomotive.
50 " " cars.
68 skips for carrying rubble stone on cars.
Blacksmith shop with 5 forges.
Machine shop, car repair shop, etc.
Track, turn-outs, etc.

The force employed varied somewhat from day to day during the period mentioned, but the following as employed during June, 1903, may be taken as a typical case:

General.—1 superintendent, 1 time keeper, 1 general foreman.
Stripping gang.—1 foreman, 4 laborers, 1 team.
Quarry.—
1 assistant general foreman.
8 foremen, one for each derrick.
14 machine drillers.
14 " " helpers.
4 hoist engineers, one for each 2 derricks.
1 " " incline plane.
5 firemen in charge of boilers.
50 or more laborers.
1 water boy.
1 watchman.
1 team.
Loading Dock.—1 foreman, 1 hoist engineer, 6 laborers, 1 watchman.
Track Repairs.—1 foreman and 3 laborers.
Blacksmith shop.—1 foreman, 3 blacksmiths and 3 blacksmith helpers.
Other Artisans.—1 locomotive driver, 1 machinist and 2 carpenters.



FACE OF THE LIMESTONE QUARRY OF HUGHES BROS. & BANGS, WINDMILL POINT, ONTARIO.

VIEW SHOWING DERRICKS AND TRACK IN THE QUARRY OF HUGHES BROS. & BANGS.

The following is the rate of wages paid:

Superintendent, per month		$166.67
Timekeeper, per month		60.00
General foreman, per month		85.00
Assistant general foreman	per hour.	.30
Foreman	" "	.22½
Drillers	" "	.20
Drill helpers	" "	.15
Steam hoist engineers	" "	.17½
Water boys	" "	.10
Watchmen	" "	.17½
Teams	" "	.30
Blacksmith foremen	" "	.30
Blacksmiths	" "	.25
Blacksmith helpers	" "	.17½
Engine drivers	" "	.25
Machinists, per month		75.00
Carpenters, per hour		.17½
Firemen, per hour		.17½
Laborers, per hour		.15

Table I. shows the operations for the months of May to September, 1903, both inclusive:

*See Engineering News, May 16, 1901, for a description of the Buffalo Breakwater.

†33 Mann Building, Utica, N. Y.

TABLE I.

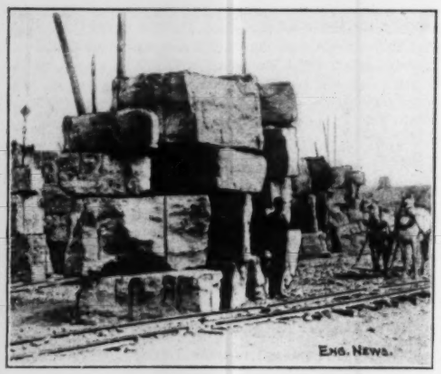
Month, 1903.	Stone quarried, tons of 2,000 lbs. Rubble.	Capping.	Total.	Cost of labor only.	Cost per ton.
May	16,535.9	None.	16,535.9	$5,127.51	$0.31
June	12,771.2	2,541.4	15,312.6	5,154.65	.34
July	11,444.4	5,273.8	16,718.2	5,438.91	.33
August	9,426.2	5,118.7	14,544.9	5,071.92	.35
September	5,937.0	2,931.9	8,868.9	3,283.85	.37
Totals	56,114.7	15,865.8	71,980.5	$24,076.84	$0.33

Month, 1903.	Days worked.	No. of holes drilled. Class of drill. A	C	F	Total.	Lin. ft. of holes drilled. Class of drill. A	C	F	Total.	Explosives, lbs. Pow.	Dyna-mite.	Gela-tine.
May	24½	513	896	556	1,965	1,385	4,757	4,840	10,982	1,691	302	211
July	24½	674	2,101	674	3,449	1,177	10,771	4,927	16,875	2,683	292	22
August	23⅞	620	1,978	658	3,256	853	10,098	4,677	15,628	2,558	117	25

During the month of May, in the early part, 1 A, 3 C and 2 F drills were used. Later in the month 2 A, 4 C and 3 F drills were used.
During the months of July and August, 2 A, 9 C and 3 F drills were used.

The following table shows the daily average operations of the drills for the months given:

Month, 1903.	No. of holes drilled daily for each drill. A	C	F	Lin. ft. of holes drilled daily for each drill. A	C	F	Average depth of hole drilled, feet. A	C	F
May	12.5	10	8.8	33.8	53.4	76.2	2.7	5.3	8.7
July	13.8	9.5	9.2	24	49	67	1.7	5.1	7.3
August	13.4	9.4	9.2	18.4	47.3	65.8	1.3	5.1	7.1



A Pile of Capping Stones for Buffalo Breakwater.

The cost for explosives, which includes powder, dynamite and fuses, per ton of stone, all kinds, quarried was:

1903.	Cts.
For May	1.3
" July	2.0
" August	2.1

About 1 lb. of powder was used for every 7 tons of stone quarried, and 1 lb. of dynamite for every 67 tons of stone.

One fuse was used for every 5½ tons of stone quarried.

The total cost of quarrying one ton of stone, loading and placing same aboard of scows, may be summed up as follows:

	Cts.
Labor	33
Coal	4
Explosives	2
Miscellaneous	5
Total	44

This is exclusive of cost of plant and deterioration.

THE USE OF A DOUBLE-CONE WASHER FOR TIMBER JOINTS.

By L. S. Austin.*

The writer has long felt that the ordinary way of securing the ends of sway braces in trestles is altogether unsatisfactory, and in many cases inadequate. In such places a ¾-in. bolt is commonly used through sway brace and post. Before this bolt can come to a bearing some movement of the bent must take place, even in the case of a freshly tightened bolt. To lessen this movement and to strengthen and stiffen the joint the writer has made use of a cast-iron double-cone washer (Fig. 1, a), which is inserted in the joint as follows: The sway brace having been set in position is tacked there by means of nails or boat spikes, and the holes bored as usual for ¾-in. bolts. The sway brace is then pried off and reversed. The countersink bit (Fig. 1, b) is used to countersink the hole both in the sway brace and in the post. The sway brace is then returned to position, the double-cone washer is dropped into the countersunk cavity and the usual ¾-in. bolts driven through and tightened.

The washer weighs 0.6 lb. The countersink bit was made for the writer for the purposes of this experiment, costing about $5.00. The dog, shown in Fig. 1, b, attached to the stem, serves as a depth gage.

*Professor of Metallurgy and Ore Dressing, Michigan College of Mines, Houghton, Mich.

To determine the strength of this type of joint, two full sized test pieces were prepared, as shown in Fig. 2. The washer used is shown in No. 63, while No. 62 represents the ordinary joint and fastening. The tests were made and the diagram prepared under the skilled direction of Mr. Geo. L. Christensen, using a 100,000-lb. Riehle testing machine belonging to the college, and the pieces were tested to destruction.

From the diagram, Fig. 2, we see that the resistances vary as the projected areas of washer and bolt. In this case with a washer 2 ins. in diameter we find, that within the elastic limit, the bolt will withstand 1,000 lbs., and with the washer it will stand 2,000 lbs.; or, that the result of using of the washer, is to double the resistance of the joint. For greater stresses the ratio is nearly the same; or, in other words, if unusual stress were brought upon the member, as by the swaying due to runaway rolling stock, it would be able to resist where, without the washer, it might fail. It is claimed for a joint thus made that the countersinking may be so regulated as to bring the washer into an initial compression, such as would prevent practically any movement within elastic limits, and thus stiffen a structure whose sway movement tends to loosen these joints.

In making up a lower truss-chord of timber this doubling of the strength of the bolts by interposing washers greatly assists in the strengthening of the notoriously weak joints. So far as a sway brace is concerned, a scantling of 8 or 10 ins. × 3 ins., giving a safe load in tension of 25,000 to 30,000 lbs. is out of all proportion to the best assistance we can get even with the use of the washer, viz., 2,000 lbs. to the bolt.

THE CONCRETE PILE FOUNDATION OF THE U. S. EXPRESS CO. BUILDING, NEW YORK CITY.

An exceedingly interesting piece of foundation work is now nearly completed for the U. S. Express Co. building, at 557 West 23d St., New York city. About 160 concrete piles are being driven by the Raymond system,* the average penetration being 25 ft. Concrete piles were selected in preference to wooden piles because the higher cost of concrete piles is more than offset by the saving in trenching, sawing off under 5 ft. of water, and the underpinning of adjacent buildings, all of which would have been necessary had wooden piles been used. Moreover, fewer concrete piles are required to secure the same bearing power for equal penetration. This is attributed to the conical shape of the piles which have a diameter of 6 ins. at the point and 18 to 20 ins. at the butt or top end. A careful test of the bearing power of one of these concrete piles was made under the direction of Mr. Charles F. Berger, Civil Engineer. The core was driven 25 ft. 9 ins., with a 3,100-lb hammer, and the penetration under the last blow was ½-in., the hammer falling 8 ft. The core was drawn, the shell filled with concrete and a platform laid on top of the pile to receive the test load of pig iron. When the load reached 25 tons there was a settlement of 1-16-in. Loading was continued until 38 tons had been applied, with a total settlement of 9-32-in. Twenty-four hours after the 38-ton load had been applied, the total settlement was found to be 13-32; and 24 hours later it was 15-32, after which no further settlement occurred. According to the Engineering News formula, the safe load would be 16⅓ tons under the conditions above given.

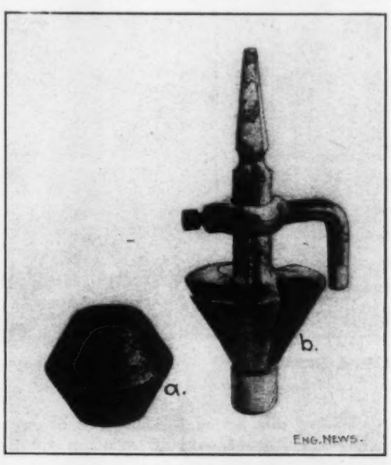


Fig. 1. Double Cone Washer, a, and Bit, b, for Countersinking.

*In Engineering News, June 20, 1901, Dec. 11, 1902, and March 4, 1904, will be found descriptions of the Raymond pile.

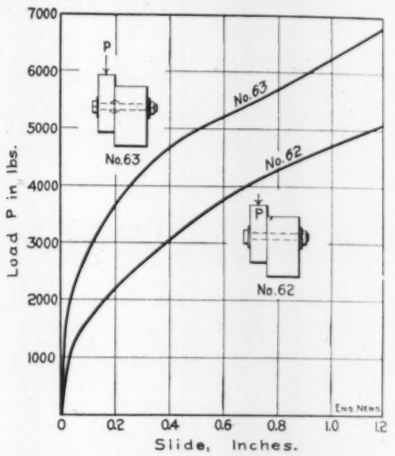


Fig. 2. Diagram of Tests on Bolted Timber Joints. No. 62 Being a Common Joint, No. 63 Being a Double-Cone Washer Joint.

The pile driver is a double-drum friction clutch machine mounted on a turntable, the framework of which rests on rollers, so that by using a rope around the winch heads the driver is quickly moved with its own power. The number of piles driven per day is now about 14 in 10 hrs., although on Oct. 1, 15 piles were driven in about 8 hours. The driving is by no means in easy earth, as there are a good many small boulders encountered. The pile driver crew consists of eight men, and the concreting gang consists of six men. A concrete pile 25 ft. long contains about 0.8 cu. yd. of 1 : 2 : 4 concrete. The steel shell for each pile is made in four sections of No. 20 steel, the sections telescoping one within the other as they lie stacked up ready for use. When the core has been pulled, it is raised until a "nest" of shells can be slipped over the lower end of the core and hoisted up around the core by means of a rope to the winch head. This whole operation occupies but a few minutes, about 4 mins., to make fast and pull the core out, and as many more minutes to slip on the shell and prepare for driving the next pile. The number of blows required to drive one of the piles was 296, the average drop of the hammer being about 5 ft. A cap with an oak striking block is used in driving.

Reverting to the conditions that lead to the use of concrete piles, it should be said that the level of permanent ground water is about 10 ft. below the surface, and possibly lower. To cut off wooden piles below this level would have necessitated deep trenching and sheeting, besides the underpinning of adjoining buildings. The driving of the row of concrete piles alongside a three-story brick

ilding has not affected its walls in the least, in te of the fact that the heads of the piles al- st touch the foundation wall of the building. o smaller brick buildings, whose walls were cked in places before the driving began, were injured by the jarring incident to the pile ing.

The U. S. Express Co. building will have no ement, and its ground floor will be paved with alt blocks so that wagons can drive in from street and unload under cover. The roof will be supported by steel trusses having a span of 75 ft., and the second story floor will be suspended from the roof trusses. The architect of the building is Mr. Ernest Flagg, and the builders are the Edward Corning Co. The subcontractors for the pile foundation are the Raymond Concrete Pile Co., of Chicago, Ill., and their superintendent in charge of this work is Mr. H. R. Mayer.

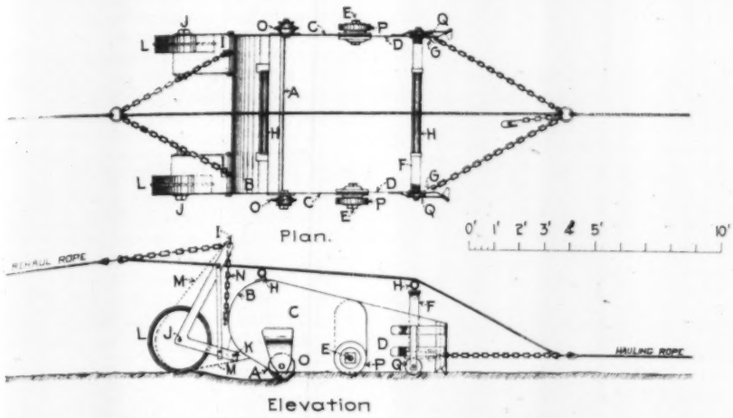


FIG. 1. PLAN AND SIDE ELEVATION OF POWER SCRAPER LOADING.

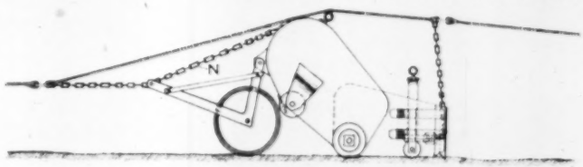


FIG. 2. POWER SCRAPER DUMPING.

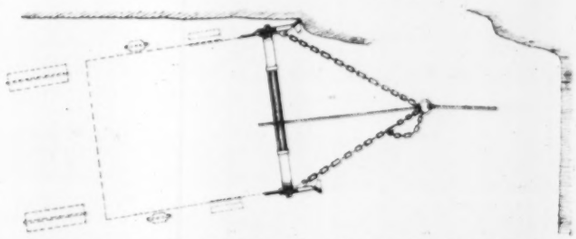


FIG. 3. POWER SCRAPER USING SIDE CUTTING-BAR.

A CABLE POWER SCRAPER FOR EARTH EXCAVATION.

By C. G. Newton,* C. E.

The accompanying sketches and photographs illustrate a steam scraper which has been used to a considerable extent on the Pacific coast, and has proved an economical machine for moving earth.

In Fig. 1, A is a detachable cutting blade of plow steel, the scraper being open forward of this blade; B is the back plate; C C are the steel plate sides, and D D are the extensions of the sides, connected to the rear by pins at E E. F is a yoke to connect the sides; G G are lugs, with pins to attach the hauling rope; H H are rollers over which passes a rope connecting the hauling and rehaul ropes. The rehaul rope is connected at I I to bell-crank levers, which are fulcrumed at J J on wheels and connected to the back plate by pins at K.

In case the scraper is to work in wet, sticky ground, the wheels L L are omitted and the levers, made of wood, strengthened and shod with iron, rest on the ground, as shown by the dotted line M in Fig. 1, and also by the photograph, Figs. 4 to 6.

Fig. 1 shows the scraper loading; Fig. 2 shows it dumping, the hauling line being kept taut and the rehaul line causing the levers to dump the scraper, afterward hauling it back in that position for another load, thus saving much wear on the scraper blade. Chains N prevent the wheels from touching the back of scraper. In case it is desired to carry dirt up an apron to dump on cars the wheels O P Q are used to clear the blade and sides. In Fig. 3 is shown the method of attaching the hauling rope to work the scraper into a bank. For this purpose the side of the scraper is bent and carries a cutting blade, as shown.

This steam scraper has been used in a variety of work and has given satisfaction under difficult conditions.

At the Lewis & Clark exposition grounds, near Portland, Oregon, the scraper was used to dredge Guild's Lake, the material being conveyed 400 to 700 ft., in places in several feet of water, and dumped over a bulkhead 4½ ft. high. The bed of the lake is a foot or so of silt, overlying a very hard, stiff blue clay, very difficult to excavate. The ground was moved at cost of 14 cts. per cu. yd., and, with everything in good running order, at the rate of 600 to 800 yards per day. It is probable that no other machine on the market could have done the work under these conditions so quickly or cheaply. The photographs, Figs. 4 to 6, show the scraper at work on this job.

At La Grande, Oregon, it was used to load ballast cars for the Oregon Railway & Navigation Co., digging gravel from the bed of the Grande Ronde River, in several feet of water, carrying it 200 ft. up an apron and dumping on the cars. Under these conditions it loaded cars at the rate of one 30-yd. car every 16 mins., and as it took 4 mins. to move the cars, the actual average loading time was 12 mins. The cost per yard, loaded, was 7 to 8 cts.

The scraper has also been used for street grading, etc. The following is an estimate of cost per cu. yd. of moving dirt, sand or gravel under average conditions, with 400-ft. haul:

Cost of donkey engine	$2,250.00
" 4½-yd. scraper	500.00
" lines	500.00
" blocks	150.00
" extras	300.00
Total cost of plant	$3,700.00

	Per day.
Daily interest on capital at 8%	$0.81
Depreciation, donkey engine	1.25
Depreciation, rest of plant	7.95
Wages, 1 foreman and signalman	3.50
" 1 engineer	3.00
" 1 fireman	2.50
" 1 line tender	2.50
Fuel, 1 ton coal	5.50
Oil and supplies	1.00
Repairs to lines, etc	2.50
Daily expenses	$30.51
Average load, cu. yds	3
" No. per 10-hour day	135
" cu. yds. per day	405
" price per cu. yd. moved, cts	7.53

In general, it may be stated that this scraper can be used most profitably in a big yardage, long-haul job. For small work, where much shifting of engine and dead-men is required, it will save little over other methods; but for large railroad cuts, irrigation ditches, canals, etc., it is a very efficient machine.

The machine is made in several sizes by the Hammond Mfg. Co., Inc., of Portland, Oregon, who control the patents.

FIG. 4. POWER SCRAPER LOADED, LEWIS AND CLARK EXPOSITION GROUNDS.

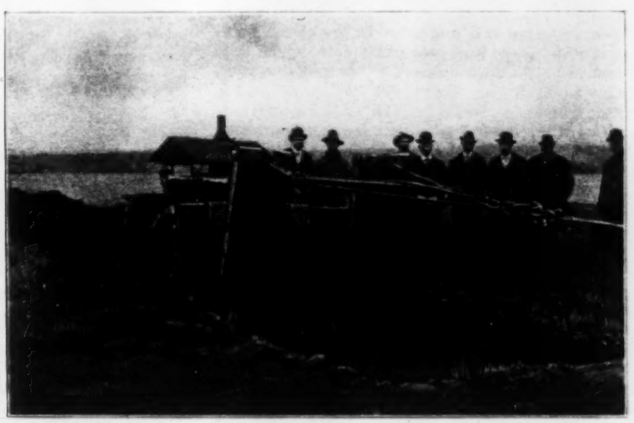


FIG. 5. REAR VIEW OF POWER SCRAPER BEFORE DUMPING.

*530 Dekum Ave., Portland, Oregon.

NOTES MADE IN BOSTON.

Few persons realize what good work the best of our municipal boards of health are doing. The very essence of some of the most effective of that work is promptness. Time here is more than money, it is life. This is particularly true of many of the culture tests made in the bacterial laboratories of boards of health to confirm the clinical

diagnosis of communicable diseases. Of the various bacterial tests made, time is of greatest importance in the case of diphtheria cultures. This is due to the rapid course of the disease, the importance of prompt treatment with antitoxin and of speedy isolation of the patient. Fortunately a diphtheria culture requires only a few hours for its development. In practice, if a physician takes a culture any time during the day and gets it to the laboratory of the board of health before closing hours, he will be given a report on the culture the next forenoon. In the case of a positive culture he can immediately isolate the patient and administer antitoxin to him or her, if deemed best to the other members of the family. The board of health is also in a position to ensure that isolation is established and maintained. Where laboratories close at the usual office hour, a whole day may be lost in securing a report on a culture taken in the late afternoon or evening. To obviate such delays provision is made in Boston* for receiving cultures after office hours without keeping a man on duty at night. An incubator is placed a few inches from one of the doors to the laboratory. A metal shute connects the incubator with a hole in the door, so a culture outfit can be dropped into the opening and pass down into the incubator at any hour of the evening. The next morning the cultures found in the incubator are examined in the course of the office routine. Whether or not this method is in use elsewhere is immaterial to the purpose of this note, which is to direct attention to one phase of the valuable work being done by our progressive boards of health. If the public, meaning thereby citizens and taxpayers, realized what is being done and how much more might be done by boards of health to protect the lives of themselves and their children, they would gladly increase many fold the appropriations for such work and would cooperate with health boards more fully in their efforts to suppress disease.

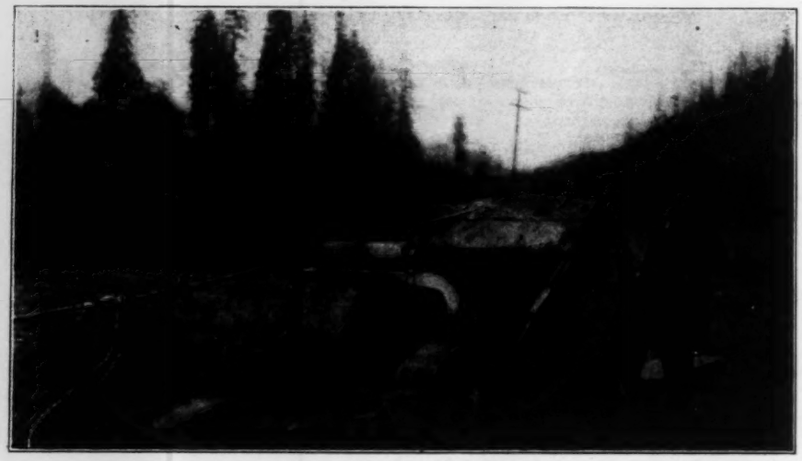


FIG. 6. POWER SCRAPER AFTER DUMPING.

The sewage experiment station of the Massachusetts State Board of Health has now been in operation some eighteen months. It is located over one of the Boston main sewers, from which sewage is raised by a small electrically driven pump. The station includes closed and open septic tanks, intermittent filters, contact beds and one or more percolating filters. A fully equipped laboratory has been provided. The station is in the direct charge of Mr. C.-E. A. Winslow and under the general supervision of Prof. Wm. T. Sedgwick. For students at the Institute the laboratory affords a fine opportunity for practical work, giving a general and a specific training in chemical and bacterial research, and having, of course, an intimate relation to sanitary engineering. A number of papers giving the results of the investigations made during the first year or so will soon be published.

The work of this station and also of the sanitary research laboratory at the Institute, has been made possible by the gift of "a friend of sanitary science and education" whose name has not been announced. The donor desires to have his gift bear fruits for the general public, as well as for specialists. Accordingly there is now being published a series of "Leaflets on Hygiene and Sanitation," prepared by the workers at the research laboratory and at the sewage testing station. The series now under way is on dirt and disease. Two have thus far been printed, both by Professor Sedgwick: (1) "Why Dirt is Dangerous"; (2) "Why Dirty Milk is Dangerous." These will be followed by leaflets on dirty water, dirty streets and dirty persons. Leaflets 1 and 2 are reprinted from the Journal of the Massachusetts Association of Boards of Health, and can be obtained in quantities at a nominal price by addressing the Biological Department of the Massachusetts Institute of Technology, Boston, Mass. A single milk dealer in Boston has bought a large number of copies of the "Dirty Milk" leaflets for distribution among milk producers. The gift which makes possible the work outlined in these two paragraphs, and the work itself, are worthy of emulation.

The copper sulphate method of treating water infected with algae is still being studied by the Massachusetts State Board of Health.* One of the chief objects of the studies is to determine what becomes of the copper added to the water. In making the tests for copper in minute quantities, advantage has been taken of the experience gained and method perfected a few years ago when the board was studying the effect of various waters on lead, copper and other water service pipe. The results of the copper sulphate studies will not be published for some months, owing to the time required to bring them to an authoritative conclusion.

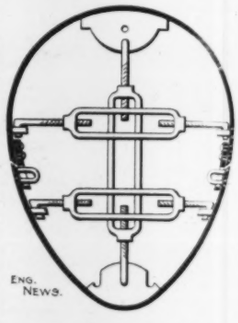
The discharge of crude sewage into any part of the Neponset River or its tributaries has been prohibited by the Massachusetts State Board of Health, in accordance with an act of the legislature approved on June 28, 1902. This includes factory wastes as well as ordinary sewage and will doubtless give rise to some interesting attempts to render wastes inoffensive.

For successful meetings of local societies, Boston is hard to beat. The Boston Society of Civil Engineers and the New England Water-Works Association have monthly meetings from cool weather until warm, which are generally well attended and productive of good papers and discussions. The New England Water-Works Association prefaces its meetings, which come in the afternoon, by a lunch and the newly-formed sanitary section of the Boston Society of Civil Engineers meets at six o'clock at the dinner table and listens to papers afterwards. To the meetings of both these bodies men come from no little distance. The early afternoon meeting, in par[ticu]lar, favors attendance from a distance, with [re]turn home the same day. Perhaps if the A[meri]can Society of Civil Engineers would chang[e] time and character of its "collations," the at[ten]ance at its meetings would also change in nu[m]character and geographical origin.

The creo-resinate wood paving laid on se[ve]Boston streets a few years ago, seems to be st[an]ing the traffic remarkably well. From a per[so]inspection and also from inquiries of s[tr]cleaners, policemen and others who have [ha]opportunities to observe, it appears that the c[re]jointed blocks on rather heavy grades have [be]quite slippery and that the more open joints h[av]given greater satisfaction. On one street [at] least, asphalt and wood blocks have been laid [si]by side. Both appear to require sanding in [wet] weather.

A STEEL FORM FOR CONCRETE SEWERS.

The accompanying sketch shows a steel c[en]or form for constructing sewers and other [con]duits in concrete. As shown by the drawing [the] form consists of a shell of steel plate bent to [the] shape of the conduit desired and braced [inter]nally by turnbuckle rods hooking into suitable eyes and bearings. The shell is made in two parts, an upper part or center and a lower part or invert form. Near its top edge on both sides the invert form is provided with hook-eyes which are headed through the shell with countersunk heads. The bottom edges of the arch center have plates riveted on their inside, which lap past the edges of the invert form and have slots through which the hook-eyes pass. Cotters through the hook-eyes clamp the arch center and invert form together. The purpose of the turnbuckle rods is to brace the shell internally and preserve its shape under load. The forms are usually made in 5 ft. sections. They are patented by Thomas A. Burrows, 922 Drexel Building, Philadelphia, Pa., who builds them to order for any size and shape of conduit.



ESTIMATING DISTANCES.

Commander Wm. H. Beehler, U. S. N., contributes to the U. S. Naval Institute, of Annapolis, Md., an interesting paper upon estimating distances for gun-fire, which is printed in the Proceedings of the Institute for June, 1904. As a portion of this paper might be useful to civil engineers as well as to gun-pointers, a brief abstract is here given.

Commander Beehler, in one of his cruises, adopted a simple method for estimating distances with very considerable accuracy. The method consisted in getting two lines of sight on a distant object, one with the right and the other with the left eye. The observer extends his right arm with the forefinger pointing to the object, and sights with his right eye along the arm. Then, holding the arm and finger rigid, he closes his right eye and sights with his left eye over the point of the forefinger. He finds that the second sight-line will point to the right of the distant object a distance equal to one-tenth of the distance of the object from the observer. The lateral distance to the right must be estimated; and the accuracy of the estimate depends upon practice in observing distant objects of known dimensions. The lateral error is, of course, magnified ten times when applied to the horizontal distance between the observer and the distant object.

The basis of this method lies in the fact that the two eyes are normally 2.75 ins. apart; and the right forearm extended will bring the point of the right forefinger 27.5 ins. from the right eye. If lines be drawn between the two eyes, from the right eye to the object, from the left eye over the right forefinger, and between the distant object

*Dr. Hibbert Hill, Bacteriologist, and R. B. Rickards, Assistant, Boston Board of Health.

*Mr. X. H. Goodnough, M. Am. Soc. C. E., Chief Engineer; Mr. H. W. Clark, Chemist.

nd the point to the right struck by the second ght line, we have two right-angled similar tri gles, in the smaller of which a proportion of to 1 exists between the base and altitude; and nsequently there is the same proportion be- een the similar sides of the larger triangle.

As men are not uniform in size, and the dis- ce between the eyes is not always the same, e ratio must be determined in each case. But e proportion of 10 to 1 should be retained as the ost convenient, even if the point of intersection the left eye sight has to be prolonged by the e of a lead pencil, or other object.

In principle this method of Commander Beehler is similar to the old topographer's manner of esti- ting distances by the use of a string and a duated lead-pencil. As doubtless many of our readers know, in this latter method a knotted string is used attached to the pencil at one end, and the knot at the other end held in the teeth. In this case, the pencil—which is held vertically at arm's length, has been previously graduated by observing familiar objects at known distances; these objects being a man on foot or on horseback, the ordinary height of a fence, or any common object that may be selected. The graduations on the pencil then correspond to known horizontal distances. To use this method, the pencil is held out at the known distance from the right eye—as fixed by the knotted string, and the line of sight to the top of the distant object runs over the top of the pencil, holding the arm rigid, the thumb is then slipped down until the second sight-line strikes the foot of the distant object; the position of the thumb then fixes the horizontal d stance. The difficulty in using this method with any assurance of accuracy is the difficulty of always finding an object of known altitude to sight at.

A UNIVERSAL DRAWING DICTIONARY.*

By George H. Follows.†

Part II. Letters and Lettering.

29. The style of lettering used in the printing of this paragraph is particularly rich in letters that give shape and individuality to words. Take the word "sprightly," for instance: Seven of its nine letters either rise above or fall below the line, so that the complete word has a shape peculiar to itself. We recognize it at a glance, just as we do the face of some one we know; no more need to spell the word out letter by letter than to examine the face feature by feature; one look at the general shape is enough.

30. In reading this style of lettering we unconsciously recognize the words by their shape, and read the sentence phrase by phrase rather than word by word; so that the meaning is easily absorbed as the eye passes along the line.

31. THE STYLE OF LETTERING USED IN THIS PARAGRAPH—AND THIS IS A STYLE THAT UNFORTUNATELY HAS HAD A LONG RUN OF FAVOR IN DRAFTING ROOMS FOR NOTES ON DRAWINGS—ROBS THE WORDS OF ALL SPECIAL SHAPE OR PECULIAR OUTLINE, AND GIVES THEM A PAINFULLY MONOTONOUS SIMILARITY. IN READING THIS LETTERING WE UNCONSCIOUSLY SPELL THE WORDS OUT LETTER BY LETTER, AND READ THE SENTENCES WORD BY WORD INSTEAD OF PHRASE BY PHRASE. SUCH READING IS TIRESOME, BECAUSE THE MIND IS SO BUSY DECIPHERING WORDS AND PHRASES THAT BY THE TIME THE END OF A SENTENCE IS REACHED THE FULL MEANING OF IT IS RATHER MORE THAN LIKELY TO BE LOST.

32. All notes on drawings should be in a style of lettering that is easy to read; this is the first requirement. And the lettering should be easy to write, both well and uniformly.

33. In Fig. 4 two styles of letters and lettering are shown: One for all notes, and one for titles and headings. The lower case letters have the advantage already described of giving individuality and shape to words; notes written in this style are very easy to read. The letters are so free from ornamental or superfluous features that they are equally easy to write; and the ideal simplicity of their construction leaves so little room for variety in the shaping that different men readily learn to write them alike. The capital letters, though unsuitable for notes, serve well for titles and headings.

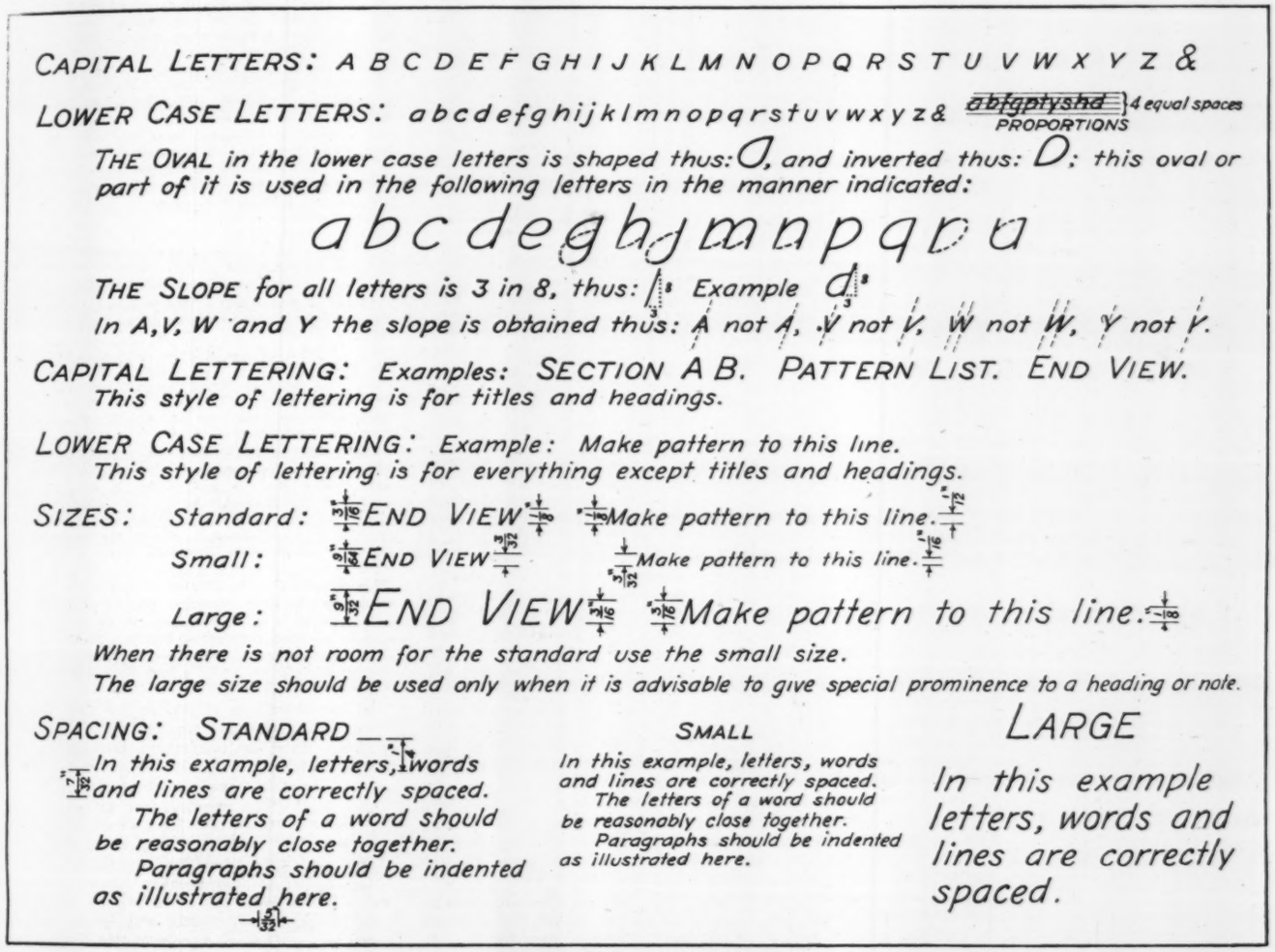

CAPITAL LETTERS: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z &
LOWER CASE LETTERS: a b c d e f g h i j k l m n o p q r s t u v w x y z &
4 equal spaces
PROPORTIONS
THE OVAL in the lower case letters is shaped thus: a, and inverted thus: o: this oval or part of it is used in the following letters in the manner indicated:
a b c d e g h j m n p q r u
THE SLOPE for all letters is 3 in 8, thus: Example
In A, V, W and Y the slope is obtained thus: A not A, V not V, W not W, Y not Y.
CAPITAL LETTERING: Examples: SECTION A B. PATTERN LIST. END VIEW.
This style of lettering is for titles and headings.
LOWER CASE LETTERING: Example: Make pattern to this line.
This style of lettering is for everything except titles and headings.
SIZES: Standard: END VIEW Make pattern to this line.
Small: END VIEW Make pattern to this line.
Large: END VIEW Make pattern to this line.
When there is not room for the standard use the small size.
The large size should be used only when it is advisable to give special prominence to a heading or note.
SPACING: STANDARD
In this example, letters, words and lines are correctly spaced.
The letters of a word should be reasonably close together.
Paragraphs should be indented as illustrated here.
SMALL
In this example, letters, words and lines are correctly spaced.
The letters of a word should be reasonably close together.
Paragraphs should be indented as illustrated here.
LARGE
In this example letters, words and lines are correctly spaced.

FIG. 4. LETTERS AND LETTERING.

34. The writer believes that for mechanical drawing, sloping lettering is better than vertical. An argument used by those who favor the vertical lettering is that there is only *one* vertical as against *any number* of slopes, and that it should therefore be easier to teach and get uniformity with the vertical lettering. But as a matter of fact, it is probably easier to get a sufficiently uniform slope than a sufficiently exact vertical, because a very slight deviation from the vertical is noticeable. In the average mechanical drawing there are so many truly vertical lines to compare with that the eye more readily detects a deviation from the vertical than from any given slope. Then again the sloping lettering stands out more clearly by contrast with the vertical and the horizontal lines of the drawing. However, in this matter, which is really one of *style* not in any way affecting the language proper, drafting rooms may be left to make their own choice. In this "dictionary" no attempt will be made to settle questions of style.

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†Of the Mechanical Engineering Department, Westinghouse Electric & Manufacturing Co., The Park View, East Liberty, Pa.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY MECHANICAL AND ELECTRICAL ASSOCIATION.

The annual convention was held at St. Louis, Mo., Oct. 10 and 11, the meetings being held in the reading room of the Transportation Building at the St. Louis Exhibition.

The opening meeting was called to order at 11 a. m. by the President, Mr. E. W. Olds, of the Milwaukee Electric Railway & Light Co. An address was delivered by Mr. John I. Beggs, President of the same company, who is well known as one of the leaders in street railway and electric railway development. After referring to the importance of the work of the mechanical and electrical departments in relation to the prosperity of the railways, he took up the question of the inspection of equipment, particularly in regard to damage cases. In many cases the railway company cannot prove that the controller apparatus or the brake rigging of a car were inspected and found in good condition, and is held liable for a negligence of which it may not be guilty, but which it cannot disprove. Thus the inspection has an important relation to the general management of the road as well as to the efficiency of operation. He considered the mechanical and electrical departments weak, however, in not systematically training men for the higher positions; good men are essential in the car houses as well as at the main shops, and foreman should have the capacity to take the place of the master mechanic or the mechanical superintendent when the opportunity offers. For this he must have administrative ability as well as mechanical ability. The mechanical equipment has not kept pace with the increase in power; double-truck cars of 40 tons weight with four 40-HP. motors (which exert three times their nominal power on curves) are operated by practically the same form of trolley wheel and controller as older and lighter cars. He thought that improvements must come largely through the work of the railway staff, as manufacturers will usually make changes and improvements only under compulsion.

This association is an offshoot of the American Railway Association, and Mr. Beggs strongly urged that it (and the Street Railway Accountants' Association) should unite with the parent association, but as branches or divisions. Then the annual meeting can be held for a week, with separate days for the meetings of the general association and the branches representing the mechanical, electrical, construction, track and accounting branches. Returning to practical matters again, he suggested that changes in the form of wheel flanges are necessary to enable cars to be safely run at the speeds and on the curves which are now becoming common practice. This will involve changes in city track construction and the abandonment of the grooved rail. For his new 7-in. T-rails with 3-in. heads he is using wheels with a 3-in. tread and 1-in. flange. He has not laid grooved rails for about eight years, but the construction adopted is approved by the city.

Mr. W. Caryl Ely, President of the American Street Railway Association, and of the International Electric Railway Co., at Buffalo, followed with an address endorsing Mr. Beggs' ideas as to the re-affiliation of the separate associations, and showing that some of the papers prepared for the St. Louis meeting of the parent association should be read before the men of the mechanical departments. The presidential address was then read by Mr. Olds, referring to the development of the interurban electric railway, and pointing out the deficiencies of the trolley system for high-speed service.

At the afternoon session, the secretary's report was presented, showing that the association has 150 members and a cash balance of $403. A constitutional amendment admitting officers of the maintenance-of-way department to membership was passed, and it was voted that a committee should be appointed to confer with committees of the other associations in regard to re-uniting with the American Street Railway Association.

CAR SHOPS.

The first paper was on "The Ideal Shop," by Mr. W. D. Wright, Superintendent of Equipment of the Rhode Island Co., Providence, R. I. The plan presented showed two parallel one-story buildings 100×380 ft., separated by a 45-ft. space for a transfer table. One building contains the blacksmith, machine and erecting shops, with stock and armature-winding rooms; the other building contains the woodworking, upholstering and painting shops.

I should prefer a width of building sufficient to accommodate two double-truck, or three single-truck cars on a tract, which would permit of shifting a car without disturbing more than one or two others. I would advise brick construction, with a plank roof, covered with tar and gravel. The roof covering the transfer track can be built entirely of metal, in which case the two main shop buildings would not be connected by any inflammable material. Granolithic cement makes a good, clean and durable floor. The only objection that I know of is that workmen, when obliged to stand on it all day, complain that it affects their feet and legs. Grooved rails should be used with this floor to prevent chipping by the wheel flanges. Tracks should be well spread, to give plenty of room between cars; 13-ft. centers are very convenient.

Partitions separating the different departments can be built of a single layer of four-compartment vitrified building tile, which can be taken down easily, as changes and extensions become necessary, and used over again. Swing windows, operated from the ground floor by a system of rods and gears, will give both light and ventilation to this portion of the building. Swing doors with two truss rods are most serviceable and durable. They take up room when open, however, and no doubt for this reason many would prefer the metal shutter.

Heating can best be accomplished by steam, unless the climate is mild, when a hot air circulating system might be preferable. A good sprinkler system should be installed in the shop buildings, with a hydrant system for hose in addition. Of course our ideal shop would be fitted with the most approved types of cranes, air hoists and general machinery for doing good work expeditiously; and a storage yard adjoining will be found quite necessary for wheels, scrap iron, etc., and should contain a good platform scale.

The members were not slow in the discussion of this paper and the criticism of the plan presented. Mr. Mundy did not approve of putting two or three cars on a shop track, but preferred only one car to each track. It is not well to do all work from the pit, where the men have to look upward; on the other hand, to do work from above, through the floor of the car, results in bringing a great deal of dirt into the car; he believed in doing as much work as possible from the floor level. Another member remarked, however, that until a standard truck design is adopted, the construction of the truck will largely govern the methods of inspecting and repairing it. To take the trucks out from under the cars is often inconvenient, especially if both are taken out at the same end, when the car has to be jacked up very high to allow the trucks to clear the brake apparatus, etc. One member favored transfer tables for running the trucks out sideways. Mr. Mundy suggested a shop with a longitudinal track along one side and repair tracks at 45°; this would place the cars so that the trucks would not be opposite, and gangs on adjacent cars could work without interference. Beyond the ends of the tracks would be a space for machine and other bench work, and next to this a space for stock, with an upper story for armature repairs. The amount of special frog and switch work was considered a disadvantage for this plan. Another member thought a 45-ft. space for the transfer table insufficient, in view of the use of long cars; he also preferred putting the woodworking and machine shops in a two or three-story building at right angles to the main shop. As to slow-burning mill construction and steel construction, both were advocated by different speakers. At the close of the discussion it was voted to appoint a committee to report upon the question of shops and shop buildings.

CAR WHEELS.

A paper on the design and wear of car wheels was read by Mr. J. Millar, Superintendent of Rolling Stock of the International Railway, Buffalo, N. Y. The following is an abstract:

The ordinary chilled iron wheel with 1-in. flange is ruinous to special work in the city. We formerly used 450-lb. and 500-lb. chilled iron wheels with 2½-in. tread and ¾-in. flange. With both of these we had unlimited trouble with chipped flanges, having to remove many of them for this reason before they were half worn out, and in several instances after making but a few trips. As a matter of precaution, I found it necessary to have all wheels carefully examined each trip at both ends of the lines.

We are now using two types of wheels under our interurban cars; steel tired and rolled steel wheels, with 3-in. tread and ⅞-in. flange. The rolled steel wheels have given very fair results, with the exception of a few which had to be removed on account of defective plates or flange wear, the results with both have been very good. The rolled steel wheels made an average of 35,000 miles before they were taken out to be turned up for the first time, and a few have been turned up the second time, with an average of 25,000 miles for the second run. We have only one car equipped with steel tired wheels that has been in service long enough to get any definite data on wear of flange and tread. These wheels have given a service about 5½ months and have made 34,500 miles. The flange wear is very satisfactory, but the flange is lower after having been in service than it was originally, although I use a brake shoe that does not wear on the flange. This I attribute to the special work inside the limits, the depth of the groove not being enough to maintain a ⅞-in. flange. However, we now have no broken or chipped flanges, and the only examination necessary now is for flange wear, which is done in the car stations, whereas, as is stated above, chilled wheels had to be examined each trip at both ends of the line.

With both the steel tired and rolled steel wheels we find that the flanges wear thin on one side of the car, while on the opposite side they are in good condition, necessitating their removal to be turned up sooner than the general wear would warrant; this I attribute, to a large extent, to the constant running of the car from the same end, which is well known to cause irregular wear. There are two arguments strongly in favor of the steel tired and rolled steel wheels: (1) the factor of safety; (2) their freedom from flat spots. During the 14 months we have had them in use I have not had to remove a single pair on account of being flat.

As to the chilled wheels, we are to-day using far better wheels than ever before. This is evident from the fact that the manufacturers have, during the past decade, raised their guaranteed mileage from 20,000 to 40,000 miles. I have had the mileage taken of 1,458 cast-iron wheels (of the 400-lb. type, standard for our city cars) which were removed during the past two years. These wheels made a total of 58,340,478 miles, or an average of 40,014 miles per wheel. Of this number 24 were removed on account of having been broken, 186 for chipped flanges and the balance, 1,248, were worn out.

In regard to flat wheels, if, when first noticed, a good wheel-truing shoe is applied, much trouble can be warded off; but if too flat for a wheel-truing shoe, grinding is the only remedy. From my experience with the grinding of chilled wheels I strongly advocate their being reground, providing the regrinding is done in time, though I am aware that quite a number of heads of mechanical departments are of an adverse opinion. It is impossible for me to give accurate figures here as to the length of time required to grind flat spots out, owing to the variance in the flats themselves; however, on averaging the time, I can safely say that to regrind a pair of wheels on account of "slid flat" with a spot about 1½ ins. long, it will take about 30 minutes actual grinding.

In the discussion it was stated that the steel wheel had advantages for city as well as for interurban lines, as its strength enables a smaller flange to be used, and many cities would not permit a flangeway large enough to take a cast-iron wheel of the size required for proper strength. One member stated that steel wheels will run 50,000 to 60,000 miles without re-turning, while chilled cast-iron wheels will not make more than 40,000 miles; another speaker, however, gets 50,000 to 60,000 miles out of cast-iron wheels with a 1-in. flange. Much trouble was experienced until gages and steel tapes were provided and manufacturers required to properly test and mate the wheels before shipping. One elevated railway has its wheels ground every two weeks, as they develop flat spots very rapidly and then become very noisy. When necessary to turn up the wheels, a high-speed steel is used. As to wheels on one side wearing more than those on the other side, it was pointed out that curves, brakes, the conditions of service and of braking, the character of the brasses, and other factors all affect the wear of wheels. This paper was reviewed by Mr. Beggs in his address to the association, pointing out that the wheel cannot properly be considered apart from its relation to the rail and track, and we quote his remarks as follows:

Mr. Millar sees one phase of this industry in discussing car wheels. He writes this paper as a master mechanic and he has got up to a ⅞-in. flange on a car wheel. The time is coming when you must have a different class of track construction in cities, and you cannot continue to run these high speed interurban cars around sharp curves than any steam road would attempt to operate, or at speeds equal to steam road practice, with a flange only ⅞-in. deep. That brings up the question of a diffe-

class of track construction in your cities. It is going to require persistent, intelligent work to have the municipal authorities recognize that we are up against a difficult condition of that kind now. Mr. Millar's paper shows that one of the troubles with the wheel is that when he gets into grooved rail construction, the flanges are worn by running on the bottom of the groove. Some of you gentlemen are not taking into account how much of the head of the rail we expect to wear off in the course of the life of the rail. Where will that groove be after 10 or 15 years' use, which we must get out of the rail if we are to secure a proper economy in our investment?

At the second day's meeting a paper on "Maintenance and Inspection of Electrical Equipment," by Mr. John Lindall, General Foreman of Shops of the Boston Elevated Ry., was presented. It dealt with methods of inspection and repair, the keeping of records of this work, and the proper training of motormen. It brought out an extended discussion of these matters, with statements of individual practice and opinion. Some members did not see the necessity of a technical training for motormen, but others considered this very important in view of the value of the property which they handle, the relation which their efficiency bears to maintenance and operating expenses, and also their relation to the efficiency of the service; since a man who does not understand the apparatus may block the line on account of a trivial defect which a properly-trained man could remedy in a few minutes. One member thought that the ordinary type of platform controller is becoming too bulky and too heavy for modern high-power cars and favored an automatic control system with apparatus under the car.

At a later meeting, in conjunction with the Street Railway Accountants' Association, a report of a joint committee of the two associations on "Blanks for Shop Records and Accounts" was presented, and it was pointed out that this is only the beginning of an important work in developing simple and economical methods of determining actual cost of work in the mechanical department.

Officers were elected as follows: President, C. F. Baker, Boston; Vice-Presidents, H. H. Adams, Baltimore; John Millar, Buffalo, and F. D. Simmons, Milwaukee; Secretary and Treasurer, S. W. Mower, Detroit, Mich.

THE VIRGINIA ANTHRACITE COAL FIELD.

By L. L. Randolph,* M. Am. Soc. C. E.

It has been assumed for years that the only fields of anthracite coal were those of Pennsylvania, but there has recently been brought to light, or one might almost say rediscovered, a field of small extent in southwestern Virginia, which promises to be interesting for many years to come. This field was first discovered fifty years ago, and since then has been mined constantly, but only for local consumption.

Prior to the Civil War two operators had sunk slopes in this field to a depth of 400 to 500 ft. Coal from these slopes was in the bunkers of the "Merrimac," or more properly speaking the "Virginia," when she had her fight with the "Monitor" in Hampton Roads. After the war this coal field lay almost entirely unknown, except for the immediate local market. Slopes were sunk, but were seldom carried more than 100 to 150 ft., 200 ft. being the maximum. The limited market, owing to the inadequate transportation facilities—all coal having to be teamed four or five miles to the railroad—together with the limited knowledge of the native miners, prevented any development being carried further than above described.

Among geologists the field has been considered more of a freak than anything else. Coal occurs in the Pocono sandstone in the Pennsylvania region, where it has been reported as 1 to 2 ins. thick, and in West Virginia, where it occurs in Meadow Branch Valley, a few miles south of Cherry Run, on the B. & O., the seam being about 18 ins. thick, but inverted and very much distorted. It has been discovered west of Winchester, in Highland County, and west of Salem, in Roanoke County; but the only workable deposits are in Montgomery and Pulaski counties, disappearing in Wythe County. The field has been examined from time to time by promoters, but has been turned down by capitalists—in most cases for the reason, as tersely given by one, that "it was impossible for so good a thing to have laid so long without having been opened up." All of this formation is broken and distorted, with the exception of the Pulaski and Montgomery counties, and even there, in many cases, it is distorted and broken to such an extent that mining is unprofitable even in face of the fact that good prices can be had for what coal is turned out.

*Blacksburg, Va.

Figs. 3, 4 and 5 show cross-sections of these different fields. These fields of mineable coal are known in this region as the Price Mountain, the Brush Mountain and the Pulaski fields. The Price Mountain fields occurs in a spur running parallel to Brush Mountain and here the upheaval has caused the coal to outcrop on both sides of the mountain. Price Mountain is six miles east of Brush Mountain and the anticlynal axis of the basis is coincident with the axis of the mountain. So far as discovered, there is no parallel formation either east or south corresponding to the mountain. In other words, this coal field has only one outcrop, which lies on Brush Mountain, and Little Walker Mountain, except where the above-described outcrop on Price Mountain occurs. There are five seams in this outcrop varying in thickness as follows:

No. 1, or the topmost seam, is 5½ ft. thick; No. 2 is 2 ft. 3 ins. thick; No. 3 is 6 ins. thick; No. 4 is 4½ ins. thick; No. 5 is 2 ins. thick.

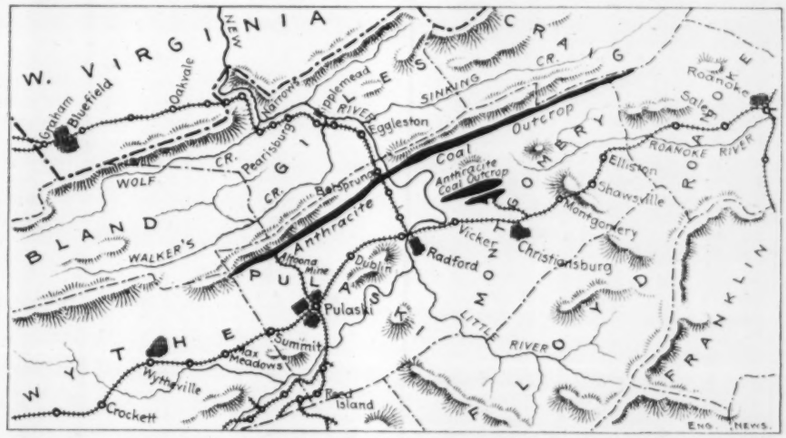

FIG. 1. MAP OF VIRGINIA ANTHRACITE COAL FIELD.

No. 1 only is mined in the Price Mountain field, but in the Brush Mountain and Pulaski fields, both No. 1 and No. 2 seams are mined. Particularly in parts of the Brush Mountain field, where the No. 2 seam widens out to 3½ ft., and, as it has only one thin slate parting, can frequently be mined to greater advantage than the larger seam.

The character of the coal in the veins varies very much from top to bottom. In the sections shown of the Brush Mountain field the coal near the bottom is rather soft and tender, but very low in ash, sometimes running as low as 3 or 4%. As we go toward the top of the vein the coal becomes harder and higher in ash. The slates are all rather dark in color, and some of them are so filled with bituminous matter as to make it practically impossible to tell them from the coal, except by their weight and their flinty character. Some of these bands of slate are made up of small pieces, which are covered with a thin layer of coal, making it impossible for the ordinary person to recognize them as slate. The gravity of slate is very much greater than coal, making automatic separation very easy. The coal is very light, the most marked difference between it and the Pennsylvania coal being in this characteristic. A 60,000 lbs. capacity car seldom will hold more than 55,000 to 57,000 lbs. of coal. The fossils of this formation are comparatively few. The fire clay which overlies the coal is filled with grasses. In many cases ferns are found in the slate bands and in the formation immediately under the coal. The fronds of these ferns are blunt, not pointed, as in the ferns of the present day. One or two quite large sections of the lepidodendrids have been found. These are all of the fossils so far discovered. No mollusks, or similar animal life, have been brought to the writer's attention. It should be said that these deposits are near the summit of the Alleghany Mountain, or rather on the divide separating the waters of the Roanoke River and the New River, the former employing its waters into the Atlantic Ocean and the latter into the Gulf of Mexico, thus forming the summit of the Alleghany Mountains.

The total estimated acreage of the Montgomery field is about 7,000 acres. This includes the coal between the coal outcrop and the limestone outcrop. Indications are that the coal is mineable within a few hundred feet of this limestone fault; hence the entire region between the coal outcrop and the limestone fault is included. On this basis the total estimated tonnage of the Blacksburg field would be 70,000,000 tons in the big seam alone, with possibly 25% of this amount available from the little seam, making a total of 100,000,000 tons of coal in the Blacksburg field alone. The developments in the Pulaski field are not sufficiently numerous and recent to enable us to fix any definite tonnage on this field are too uncertain to be trusted. This estimate also throws out considerable property where the strata are so faulty and broken as to make mining impracticable. The extent of the deposits of the Pulaski field is yet to be determined, but it is almost as extensive as the Montgomery field. It extends and has been more or less developed from New River to the city of Pulaski, but all operations except those at New River have been practically abandoned. The coal, as shown by chemical analysis and by its physical characteristics, has rather a striking resemblance to the deposits in the Lykens Valley region of Pennsylvania. In fact, it is almost impossible to tell the two apart. Its luster is not as great, however, as the usual run of Pennsylvania coal, nor is the fracture so decidedly conchoidal. It is more tender and carries more volatile combustible, but it gives absolutely no smoke, except with very careless firing; chimneys are entirely free from soot, and the ash is white, though in some places there is sufficient iron to give it a reddish tinge. For ordinary domestic purposes there is little or no clinkering, except where fires are very heavily forced. Certain constituents of the ash seem to melt and form just the right amount of clinker to give satisfactory results for steam boiler work. The chemical composition is shown by the following result obtained from samples selected by the writer:

	Price Mountain.	Brush Mountain.	Pulaski
Volatile combustible and moisture	10.2	9.3	10.7
Fixed carbon	79.4	79.6	73.1
Ash	10.4	11.1	17.2
	100.0	100.0	100.0

The above represents average results obtained from analysis made by the writer and by Prof. Robert C. Price, of the Virginia Polytechnic Institute. The coal seems to carry a considerable amount of occluded gases, but only at one point, viz., on the south side of Price Mountain, at the

Merrimac Mines, has fire-damp been discovered to an appreciable extent.

The development of this region has been very singular, as previously stated, the coal being mined extensively prior to the Civil War. The late Mr. Montague, of Christiansburg, Virginia, and Mr. Isaac Adams, now a resident of Lynchburg, Virginia, were the principal operators at that time. After the war the seam was opened up in Pulaski County at Bell Hampton, a narrow gage road was constructed to carry the coal to the Norfolk & Western. The seam was also

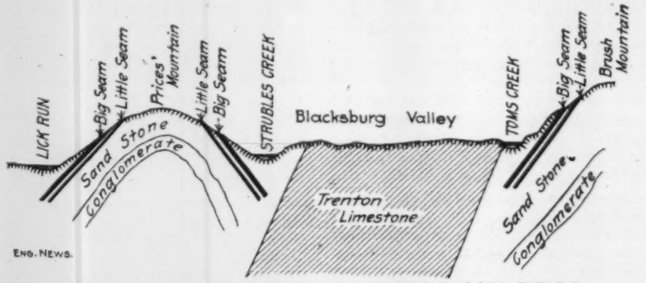

FIG. 2. SECTION THROUGH BLACKSBURG COAL FIELDS.

opened up in Pulaski County at Dry Branch, or Kimball, on the Norfolk & Western, where it runs along the banks of the New River. Of these operations, the latter is the only one which has been able to keep going. The Brush Mountain and Price Mountain fields have been operated in a small way almost continuously since the war. An examination of the cross-section of the Pulaski field will show the principal defect is in the large seam of dirt which occurs in the coal. It has been stated that this could not have been operated successfully had this bituminous slack, or dirt, not been useful in some neighboring metallurgical operations.

In 1898 the Brush Mountain Coal Co. was organized, with L. S. Randolph president, Guy F. Ellett secretary and treasurer, and J. W. Walters and Dr. R. T. Ellett as directors and stockholders. These gentlemen purchased a large amount of the Price Mountain field, which, being much nearer to the Norfolk & Western than the rest of the field, and controlling the only feasible route for a railroad through Price Mountain, practically controlled the situation. These gentlemen carefully studied the region, and to them is due the development of the field. In 1902 Mr. W. J. Payne, of Richmond, Va., leased the holdings of the Brush Mountain Coal Co., and has since acquired, by lease or purchase, practically all of the Brush Mountain field. The Virginia Anthracite Coal & Railway Co. have built their road from Christiansburg to Merrimac Mines, on Price Mountain, and are now extending it to Blacksburg.

The Pulaski Anthracite Coal Co. have purchased the mining operations at Dry Branch from the old Kimball Co., the mines being in charge of Mr. J. H. Parrott, of Salem, Virginia. One or two other small companies have purchased small openings, but little or nothing is being done by them. The development of the Blacksburg region is being carried on by the Virginia Anthracite Coal Co., who have erected a breaker similar to those of the Pennsylvania field, which has a capacity of 500 tons a day, and is capable of being extended to 1,000 tons a day. The sizing of the coal is the same as that of the Pennsylvania field. This company is erecting a large number of laborers' houses, establishing agencies in Cincinnati, St. Louis and other points. The Pulaski Anthracite Coal Co., at Dry Branch, which is practically the only development in the Pulaski field, is also erecting a large tipple and a number of laborers' houses. The outlook in the Blacksburg field is exceedingly promising, and the indications are for a large business in the next few years.

ANNUAL MEETING OF THE RAILWAY SIGNAL ASSOCIATION.

The annual meeting of the Association was held at St. Louis, Mo., Oct. 11 and 12, the sessions being held in one of the offices of the Transportation Building at the St. Louis exhibition. At the opening session on the afternoon of Oct. 11, about 60 members were present, with the President, Mr. J. C. Mock (Mich. Cen. Ry.) in the chair. An address of welcome was delivered by Mr. Willard Smith, Chief of the Department of Transportation, in which he referred to the limited extent of exhibits in American railway signalling and interlocking plant, but called special attention to the very complete exhibit of track, signal and interlocking plant made by the Prussian State Railway, under direction of the Minister of Railways. A brief address was made by the President, Mr. J. C. Mock, in the course of which he suggested that the association ought to have permanent headquarters, where files of its proceedings and of literature relating to its work could be kept for the use of members.

WIRE FOR POLE LINES.

The report of the Committee on Wire for Pole Lines was then presented by Mr. Balliet (L. V. Ry.). The discussion turned mainly on the merits of insulated and bare wire and the proper size of wire. Some members thought that light wires collected less sleet and snow, and were less liable to break than heavier wires, but the discussion showed some confusion as to the sizes of wires, some members using the Birmingham and others the Brown & Sharpe wire gage. Mr. Elliott (N. Y. Central Ry.) introduced a motion to the effect that where there are not more than 40 poles to the mile, the wire used should be not less than No. 10 B. & S. or No. 12 B. W. G. (these sizes being very nearly alike). This motion was lost, however, and the report was finally accepted as a report of progress.

CIRCUITS FOR MANUAL BLOCK SYSTEMS.

The report of the Committee on Circuits for Manual Block Systems was then presented, and we give herewith an abstract of its several features, omitting the detail description of the operation of the various apparatus. Diagrams were given of the circuits for: 1, telegraph block; 2, telegraph block with additional communication by annunciator bells and telephone; 3, the high-speed staff instrument; 4, the lock and block system.

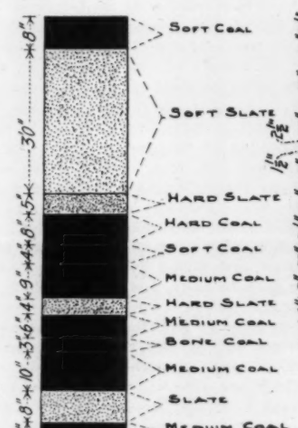

Fig. 3. Section Showing Coal Seams in Pulaski Field.

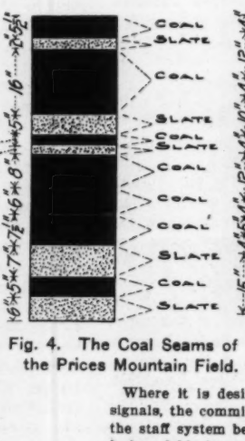

Fig. 4. The Coal Seams of the Prices Mountain Field.

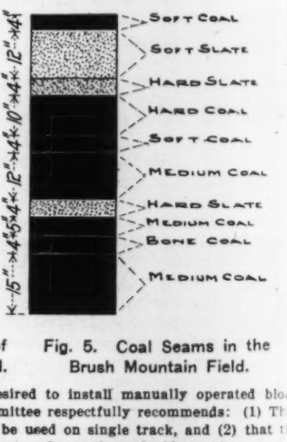

Fig. 5. Coal Seams in the Brush Mountain Field.

Manual block signals include the telegraph block and the controlled manual system. The former being the oldest and simplest requires but little explanation. It consists of a telegraph wire, called the block wire, looped into each block station, where it is connected to [illegible] relay and key, with a local circuit operating a [illegible]. The block station usually consists of a tower, two [illegible] mechanically operated semaphore signals and [illegible] graph instruments. As the telegraph block wire [illegible] busy, causing delays in reporting trains, block [illegible] are used on some roads and communication between [illegible] tions is had by the use of a bell code. The telep[illegible] has also been added in some cases to use in ca[illegible] failure, but the telephone is not used to transm[illegible] orders. The circuits for this addition are very si[illegible] require no explanation.

The staff system is used to control traffic o[illegible] track, and is more complicated than the telegra[illegible] system. The staff system is practically an absolu[illegible] system, although the instruments have a permis[illegible] tachment for permissive tablets. By this means a [illegible] train may follow, but it does not allow a train at [illegible] posite end of the block to enter until the block is c[illegible] all permissive tablets have been placed in one [illegible] of the instruments.

The staff instruments are so arranged that if [illegible] has been withdrawn from the instrument at either [illegible] of the block it is impossible to withdraw another sta[illegible] from either instrument until the one withdrawn has been replaced. The principle of this system is that to use a staff, the batteries in the instruments at both ends of the block must work together. The act of withdrawing a staff reverses a battery in the instrument from which the staff is withdrawn, and this causes the batteries to work against each other and prevents the withdrawing of any more staffs until it is again reversed by returning the staff or by putting it in the other instrument, which will reverse that battery and allow the batteries to work together again. The operation is very simple, and the staff is withdrawn and returned very quickly. There are several attachments to the staff instruments, such as the permissive, the staff and lever lock, and the instrument to be placed at outlying switches.

In the Sykes system, or what is commonly known as the "lock and block" system, each block tower is equipped with a block instrument for each track in each direction and each lever operating a block signal is locked with an electric lock. Towers are also equipped with a means of communicating between them, either by bells, using a bell code, or the telegraph or the telephone. There is a release line wire and a common return wire. There is a short track circuit immediately in advance of the block signal, which is known as the releasing circuit. This releases the block instrument in tower as train passes beyond signal, provided the operator returns his lever to the normal position and latches it. This operation locks the lever through the electric lock so that he cannot again reverse it until unlocked from the station next in advance.

Each of the instruments has a miniature indicator and a banner showing the position of the apparatus, as follows: (1) Normal position, "Free"; (2) after plunging, "Locked"; (3) when train has entered block, "Train in block." Some railways have added electric "slots" to their block signals so that trains automatically set them at "stop" and have extended track circuits entirely through the block as extra safeguards.

Where it is desired to install manually operated block signals, the committee respectfully recommends: (1) That the staff system be used on single track, and (2) that the lock-and-block system be used on double track.

The discussion turned on the committee's recommendations, as contained in the last paragraph quoted. Some members thought there were other systems which were as well-adapted for single-track working as the staff system. Mr. Dunham (Ill. Cen. Ry.), described a system installed by the General Railway Signal Co. on some single-track lines of the Illinois Central Ry., which carry a heavy traffic. This requires the cooperation of the operators at both ends of a block section in order to give a "clear" signal in either direction. It is worked permissively for freight trains, but as an absolute block for passenger trains. The machine

operate the train-order semaphore signals at stations, while signal cabins are placed at intermediate passing sidings. The blocks average four miles in length. Mr. Elliott (N. Y. Cen. Ry.) considered that the staff system gives a more complete protection than any other system, and the possession of the staff is evidence that a train has the right of way, while in case of accidents there is often dispute as to the position of signals. Another member, however, remarked that in case of a train parting, the engineman might go ahead and deposit the staff, so that a second train might run into the detached cars. This is not possible where a track circuit is used, as in the Union lock-and-block system and the Illinois Central Ry. system. Mr. Short described the successful operation of the staff and tablet system on the Cincinnati Southern Ry. Eventually it was voted to refer the report back to the committee with instructions to report upon what they consider the best practice in block signaling for both single and double track.

SIGNAL GLASSES.

At the afternoon session, Dr. Nelson M. Black, an ophthalmic surgeon, presented a paper describing tests made of different styles of colored glass for signals. A new style of "blue-white" glass gives a whiter light than the ordinary lens as it absorbs some of the yellow rays, but at the same time it is not so efficient a light. Where yellow is used for the "caution" indication, however, the blue-white would make the "clear" signal more distinctive.

STANDARD SPECIFICATIONS FOR INTERLOCKING.

The standard specifications for mechanical interlocking material and construction work, presented by a committee, were then taken up for discussion. Only a small part was discussed, and the remarks related mainly to charges in wording of the "general requirements," but they showed how difficult it is to draw up specifications which will be generally understood and which will be acceptable to both the engineer and the contractor. It was voted to take up other parts of the specifications for discussion at the quarterly meetings. Some extracts from these specifications are printed on another page of this issue.

The report of the committee on track circuits was presented by Mr. Clausen; this is not yet completed, and the report was accepted and the committee continued.

The report of the auditing committee showed that the Society has a cash balance of $835, and the report of the Secretary showed a membership of 329. It was voted that Sept. 30 should be the official end of the year, so as to allow time for preparing the reports and accounts for the annual meeting.

Officers for the ensuing year were elected as follows: President, J. C. Mock, Michigan Central Ry.; Vice-President, L. Griffith, New York Central Ry.; Secretary and Treasurer, H. S. Balliet, Lehigh Valley Ry., South Bethlehem, Pa. The next annual meeting will be held at Niagara Falls, N. Y.

ANNUAL MEETING OF THE AMERICAN STREET RAILWAY ASSOCIATION.

The annual meeting of the American Street Railway Association was called to order by the President, Mr. W. Caryl Ely, of Buffalo, on Wednesday morning, Oct. 12, in the Transportation Building at the St. Louis Exposition. The exercises opened with an address of welcome delivered by Hon. David R. Francis, President of the Exposition. Mr. Francis related some interesting inside history of the Exposition in connection with the transportation service. He said it was originally planned that the two street railway companies of St. Louis should unite in operating their own car service inside the Exposition grounds; but he returned from a trip to Europe in the interest of the Exposition to find that the street railway companies had concluded that they were not financially able to carry out the arrangement and that the Exposition managers had about decided to rely solely on automobiles, roller chairs and jinrikishas for transportation about the Exposition grounds. Mr. Francis vetoed this plan, and preparations were at once made for the construction and operation by the Exposition Company itself of an intramural railroad. This road is now carrying an average of 55,000 passengers a day, and its daily traffic averages 55 per cent. of the paid admissions. Notwithstanding its numerous grade crossings, not a person has been killed, and only three have been injured. It is the best paying enterprise of anything undertaken by the Exposition Company.

Turning to the subject of street railway management, he declared that the first essential to success is to gain the good will of the community which is served. In fact, said he, this is a most important factor in the successful operation of any public utility. He also stated that the Exposition has repaid to the Government $3,500,000 of the money which it borrowed, and would pay $500,000 more on Saturday, Oct. 15.

President Ely then introduced Prof. W. E. Goldsborough, Chief of the Department of Machinery of the Exposition, who gave a review of the principal exhibits of most interest to street railway officials. He referred particularly to the work of the electric railway test commission, and stated that among the experiments which it is shortly to undertake, will be the operation of an interurban car on an eight-mile tangent in Indiana, where speeds of 70 to 80 and possibly 90 miles per hour will be aimed at, and especial tests will be made upon the air-resistance at high speeds with vestibules of various forms.

President Ely then presented his formal address, in which he reviewed the notable events of the past year in the electric railway field, referring particularly to the undertaking by the New York Central & Hudson River R. R., of the operation of all its lines by electric locomotives within a radius of 35 miles from New York City, the beginning of work by the Pennsylvania R. R. on its tunnel entrance to New York City and the completion and early opening of the New York Rapid Transit Ry. Regarding the latter, he said that the record for rapid construction under great difficulties made by the Rapid Transit R. R., had probably never been equalled in the execution of a great engineering work. Regarding the results of the change from steam to electric traction on the Manhattan Elevated R. R. in New York City, he said that comparing 1901, when steam locomotives were in use, with the last fiscal year, the capacity of the road had been increased 33 per cent, the number of passengers actually carried had increased 30 per cent., and the expenses of operation, which were formerly 55 per cent. of the gross earnings, are now 45 per cent.

Turning to the affairs of the Street Railway Association, he said that it had become evident that the time had arrived for a radical change in the organization and a revision of its plan and scope. The growth of subsidiary societies has continued and it is now proposed to organize a society of those in charge of the maintenance of street railway track. A Street Railway Supplymen's Association has been organized, which will in future have entire charge of the exhibits at the annual convention and the provision of entertainment for the members. An examination of the published proceedings of the Association shows that for several years past most of the time at the Association's annual meetings has been spent in discussing minor technical details. These ought to be left to the subsidiary societies and the Street Railway Association itself should devote its time to such matters as taxation, municipal ownership, laws and municipal ordinances relating to street railways, and, in general, questions in which the joint action of the Association as a whole can have a beneficial effect. In conclusion, he declared that there were really no grounds for differences between the public and the street railway companies, and he urged that a better mutual understanding between the two parties be sought.

Following the President's address, Hon. Rolla Wells, Mayor of St. Louis, was introduced and in the course of a speech remarked that his father built and operated the first street railway west of the Mississippi River. It was in St. Louis and was opened July 4, 1859. Mayor Wells himself became its general manager at the age of 22.

At the meeting on Oct. 13, the Secretary, Mr. T. C. Penington, presented his report, showing a membership of 206 companies, and a cash balance of $7,646. It was voted that the censorship of the daily published report of the proceedings should be continued, but that this should apply only to the verbatim reports of discussions, and not to the general report of the proceedings. A resolution was passed in favor of the appointment of a committee to endeavor to bring together the various associations representing different departments of street and electric railways. It was also voted to appoint a membership committee which should endeavor to increase the membership, as at present only about 200 out of 700 companies in the United States are members. The report of the Committee on Rules for Conductors and Motormen reported certain changes, especially in regard to making the rules on electric interurban lines conform to the standard rules for steam roads as adopted by the American Railway Association. The report was adopted.

The papers were then taken up for consideration, and the President explained that it had been intended to have papers on steam turbines, reciprocating engines and gas engines, but that the promised papers on the two latter subjects had failed to materialize. All of these were to have been prepared by engine builders.

STEAM TURBINES.

The first paper was by Mr. R. H. Rice (General Electric Co.), and dealt only with the small sizes of Curtis steam turbines, 1½ to 300 KW. All of these are of the horizontal type, the vertical type beginning with 500 KW. The construction and the speed-controlling mechanism were described, and it was remarked that it is necessary to take in a large quantity of air for cooling the generator. The machines are built for condensing and non-condensing service, and for operating both direct-current and alternating current motors; the speeds range from 5,000 revolutions in the 1½ KW. machine down to 1,800 revolutions for the 300 KW. Several machines are in use for train-lighting, and some progress has been made in their application to other apparatus besides electric generators. This problem necessitates the development of satisfactory speed-reduction apparatus. Some of the small Curtis turbines are in operation with belt connections, giving fairly satisfactory results, and other forms of apparatus are being tried so that the builders expect to be able to satisfactorily couple the smaller sizes, at least, to slow moving machinery.

In the discussion, Mr. C. O. Mailloux stated that he had not believed the steam turbine to be adapted to direct-current work, but on a visit to Europe he had found them used quite extensively for this class of work, and had purchased two of the European 15-KW. machines. Among other uses they are applied to the driving of centrifugal boiler-feed pumps. He had seen direct-current generators of 250 KW. driven at 2,500 revolutions, and smaller ones at 3,000 to 4,000 revolutions. He had not heard of any trouble with water carried over by the steam. Mr. Hopkins, however, stated that at Columbus, O., a 500 KW. turbine had to be started up temporarily to take steam from a long line. They used superheat, and therefore no provision was made to drain the pipes, depending upon superheat to take up such condensation as would occur, but so much water condensed in the pipe that it was almost impossible to start the exciter engine. After starting the turbine, they never had trouble with a large amount of water going through. He has recently done work on two 500 KW. turbines taking steam from the same boilers and practically under the same conditions as two Green-Wheelock tandem engines, with a cylinder ratio of 6 to 1, direct-connected to two 500 KW. generators. He was surprised to find that the engine showed a higher efficiency, or used less B. T. U. per electric HP. than did the turbine. These tests were made under one-third load, half-load, full load, and 50 per cent. overload. It had been questioned whether superheating would not be of equal value to the engine as to the turbine. They found it even more so, although they found a great deal of trouble in lubricating the engine cylinders. It has been running for some months with an average of 75° to 100° of superheat, and there is still trouble in lubricating the high pressure cylinders, but the economy of the superheat with the engine is quite as marked as with the steam turbine. Mr. W. H.

Abbott (Cleveland) said that in operating two 1,500 KW. turbines with from 50° to 100° of superheat, in a number of cases they had water present in the steam; whether it is present always in a small degree he did not know, but at times the water comes in more or less, although the thermometer will be registering superheat all the time. He has also had trouble from a deposit in the oil like vaseline, which made it necessary to occasionally stop the turbine to clean out the oil chambers of the turbines. Mr. Mailloux said that what is wanted is not merely fuel economy, but the total cost per KW. per hour, which includes many factors, such as space occupied, maintenance, repairs, etc. The evidence indicates that the turbine will make up in other things for a slight discrepancy against it in steam consumption. In Berlin there is a triple-expansion, four-cylinder compound engine, 5,000 HP. which, running at very nearly full load, has developed 1 HP.-hour for something less than 9 lbs. of water per IHP. per hour, with superheat up to 600°. This is perhaps the world's record up to the present time. But that engine has 16 valves, complicated mechanism, and a great deal of lubrication was required. The cost of maintenance and the cost of the extra lubrication of the cylinders and valve motion, etc., and all the expenses connected with the operation, may make it less economical in total cost. As a consulting engineer he has had to deal with cases where the price of fuel varied from $1.50 to $15 per ton. There is a certain critical price of coal at which the reciprocating engine is preferable to the steam turbine, and a slightly higher price at which the gas engine is preferable to the reciprocating steam engine.

The second paper on steam turbines was by Mr. J. R. Bibbins, of the Westinghouse Machine Co., and opened the subject as follows:

> The service requirements of a prime mover in electric railway work are in many respects more severe than any other power service outside of the rolling mill. The fluctuations in load are so sudden and severe that the ability of the prime mover to regulate its speed is tested to the utmost. The simultaneous starting of many cars frequently creates an inordinate demand for power which can only be met by the prime mover possessing a large overload capacity. Furthermore, a high average of "all-day" plant economy must be maintained under these disadvantageous conditions.
>
> The steam turbine seems to be almost ideal for fulfilling these conditions: Its high speed constitutes an important regulating force; its overload capacity is large, and its economy under fluctuating loads is exceptional.

The paper dealt largely with the results of tests of Parsons-Westinghouse turbines. Records were also presented of the average results from 46 turbine plants of 400 to 40,000 KW. capacity, in various kinds of work. These aggregated 143,750 KW. and the working conditions ranged as follows: pressure, 125 to 200 lbs.; superheat, 0 to 180°; vacuum, 24 to 28 ins.; the highest figures represent street railway plants, except that electric lighting plants excel in the matter of vacuum. The important relations of superheated steam and high vacuum under ordinary conditions were discussed and the results of three plants in regard to vacuum were given in a table which we give in condensed form:

	1	2	3
Coal	Good	Medium	Poor
Service	Continuous	Continuous	Day
Daily run	24	24	10
Yearly run	365	300	300
Capacity, KW.	2,000	2,000	2,000
Ave. load, KW.	1,500	1,000	1,000
Price of coal	$4	$2	$1
Ave. economy, lbs. of water per KW. hour	23	22	22
Vacuum raised, ins.	26 to 28	26 to 28	26 to 28
Coal saved per day, tons	3.49	2.64	1.26
Water saved per day, lbs.	66,240	42,240	17,600
Net saving per year	$4,585	$1,084	—$122*
Net saving as interest on increased investment for 2 ins. extra vacuum	114.9%	27.1%	—3.05%*

*Additional cost instead of saving.

The author summarized the situation in regard to the steam turbine as follows:

> The facts presented seem to command respect for the turbine as a machine of wide application, rugged and permanent in construction, responsive to excessive and sudden demands, peculiarly suited for parallel operation under the most difficult circumstances, and capable of yielding commercial results under extremely unsuitable conditions. It is not, however, in the makeshift plants that the turbine can do its best work. Formerly the turbine has, in many cases, been designed to accommodate existing conditions in the plant. To-day the reverse is true. The plant is now being designed for the turbine, and the more universal this practice becomes, the more marked will be the influence of the turbine on present and future power station economics.

THE DIESEL OIL ENGINE.

This paper was read by Mr. E. D. Meier and described the American design of the Diesel engine, which is of simpler construction than the German machine; this simplification was a commercial necessity, as the cost of manufacture under the German plans would have been higher than the price at which the engine could be sold in this country. In addition to its simplicity, the American engine employs clean air for the jet which sprays oil into the cylinder, instead of using a part of the air compressed in the cylinder. The first stroke draws in a cylinder full of clean cool air, the second compresses this and produces a temperature high enough to ignite the fuel, the third is the working stroke, and the fourth stroke expels the products of combustion. The burning of the fuel continues during a period of time regulated by the governor, generally 0.1 per cent. of the stroke. The engines are guaranteed to consume not more than 8 or 9 gallons for 100 HP.-hours at full load, or 9½ gallons at half load, but the consumption has in some cases been as low as 6 gallons under full load. The largest engines in this country are of 500 HP. for the Sheboygan & Elkhart Lake Ry.; the German builders have supplied four engines of 400 HP. for the electric light and railway plant at Kieff, Russia. The engine of 500 HP. has six cylinders; three on each side of the generator. The initial pressure is about 520 lbs., reducing to 30 or 40 lbs. at the exhaust. Consideration must also be given to the fact that these engines require no boiler, condensers, coal and ash handling plant, coal storage, smokestack, and many other accessories necessary with steam engines.

A paper on "Transfers," by Mr. L. Jewell, was read by title and briefly discussed. The Committee on Prices of Girder and T-Rails presented no report, and Mr. Grant, Chairman of the Committee on Compensation for Carrying Mails, made a short verbal report of the progress made in dealing with the Post Office authorities. This concluded the general proceedings.

The officers elected were as follows: President, W. Caryl Ely, Buffalo, N. Y.; Vice-Presidents, E. C. Foster (New Orleans), John I. Beggs (Milwaukee), and Richard McCulloch (St. Louis); Secretary and Treasurer, T. C. Penington (Chicago). The nominating committee recommended that arrangements be made by which after the next annual convention the Secretary will give his entire time to the work of the Association. The selection of the place for the next convention was left to the incoming officers.

DISTANT SIGNALS WITH AUTOMATIC BLOCK SIGNALING ON SINGLE TRACK.

At the September meeting of the Railway Signal Association a report was presented as to the location of distant signals in connection with automatic block signaling on single track. It was recommended that home signals should be staggered and that distant signals should be set back about 2,000 ft. from the home, or two-thirds the distance back to the end of the overlap track circuit. If set back 3,000 ft. (the end of overlap circuit), then opposing trains could both get clear distant indications simultaneously. The report stated that the Cincinnati, New Orleans & Texas Pacific Ry. has automatic signals on 300 miles of single track, and the officers state that the capacity of the road is much greater than it was without the signals, their estimates varying from 25 to 50 per cent.

In the discussion, Mr. Ames remarked that the report says that in single track automatic blocking the distant signal does not give a true indication. He inquired whether this means that when the home signal is clear and distant signal at caution, it does not always give an indication that the first block home is clear, but the second block is occupied?

Mr. Short (C., N. O. & T. P. Ry.) replied that the indication of the home is the same as on the double track, but that with two passing trains coming to a meeting point from opposite directions, the distant signal being located at the overlap point, both trains might come to the overlap at the same time and both get the clear distant signal. When they get to the home, the home would be against them; that is what is meant by not giving the true indication. But they have got to overrun the entire block of miles before they get together. This can be obated to a great extent by locating the dist signal either outside the overlap, or inside overlap, but that means about $100 more of paratus, and the contingency happens so ra that it will not compensate for putting it in. some conditions the overlap is used at each end; others, only at one end. The overlap is used generally at both ends for the blocks between stion, and at a station block only on one end; depends on the local conditions. On very stegrades everything is overlapped.

A NEW GRAPHICAL METHOD FOR STRESSES IN THREE-HINGED ARCHES.*

By J. W. Balet.†

Some time ago the author had occasion to submit several alternative plans for a bridge composed of a series of arch spans. In the course the computations he developed a simplified graphical procedure for computing stresses in arches. The method, with modifications, is of general application to arches with or without hinges, braced or solid-rib; but as it appears in simplest form when used for analyzing the three-hinged braced arch, the following explanation of the method considers only this type of frame, leaving the application to other arches to be discussed in another article.

SINGLE LOAD ON ARCH.

RESOLUTION OF LOADS.—A three-hinged braced arch with parabolic lower chord and horizontal upper chord is shown in Fig. 1; the hinges are located at A, B and C, the end-hinges A and B being at the same elevation.

Suppose this arch, which for the present is assumed weightless, to be loaded with a single load II, at panel-point 5. As is well known, the reactions produced at A and B must pass through the hinges (A and B-C respectively) and must intersect on the load-line II. The reactions, then, are R_2 at A, and R'_2 at B, and in value they are equal and opposite to the components 2 and 2′ of the load II. These components, of course, are found be a simple triangle of forces (heavy lines in Fig. 1a).

STRESSES.—In order to find the stresses which this load produces in any member of the frame, a section is passed through the member in question, cutting the arch into two separate parts. The line a-a represents such a line of section, cutting the three members 3-5, 3-4 and 2-4. Consider, now, the right-hand part of the arch as a free body in equilibrium. The external forces on it are:

1, the load II, or in place thereof, its components 2 and 2′,

2, the reaction R'_2, and

3, the three stresses in the members cut by the section a-a.

Now, load-component 2′ and reaction R'_2 are equal and opposite, hence they balance. The remaining forces are: the load-component 2 and the stresses 3-5, 3-4 and 2-4. These four forces are in equilibrium. Force 2 and stress 3-5 intersect at b, while 3-4 and 2-4 intersect at 4; then these two pairs of forces have equal and opposite resultants acting in the line b-4. Fig. 1a shows how this well-known principle gives graphically the three unknown stresses. Drawing b-4 and 3-5 parallel to their action-lines, their directions result as marked in Fig. 1a. Then, taking the reversed direction of b-4, as the resultant of 2-4 and 3-4, these latter two forces are similarly found in direction and amount.

Or, instead of pairing the force 2 with stress 3-5, we may combine it with one of the other stresses. Thus, 2 and 3-4 intersect at d, while 3-5 and 2-4 intersect at e. Then the equal and opposite resultants are on the line d-e, and this (instead of b-4) may be used in Fig. 1a to determine the unknown stresses (see line d-e in Fig. 1-a.)

Or, again, taking moments about the intersection of two of the four forces, say about point 4, the moment of load-component 2 must be equal and opposite the moment of 3-5. This determines 3-5 at once, without involving the determination

*Copyrighted, 1904, by J. W. Balet.
†Consulting Engineer, 261 Broadway, New York, N. Y.

of the other two forces. To find 2-4 the center of moments would be at 3, and to find 3-4 the center of moments would be at e.

All of these methods give the same result. The first is the most convenient for computing the stresses in the chords, the second for computing the stresses in the web-members, and the third is of value where the intersection of the force with the member to be computed falls outside the drawing board.

The principles above explained, which contain nothing particularly new, may be applied to any number of loads just as conveniently as to a single load. The procedure, in case of more than one load, appears to the writer to be novel, and to have value because of its simplicity, especially as it treats partial loading (live-loads) very much more simply than the graphical methods hitherto used.

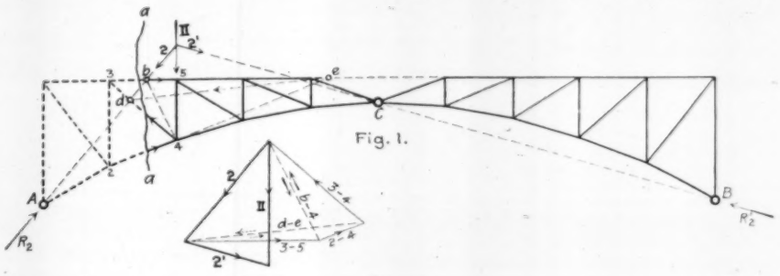

Fig. 1.

Fig. 1a.

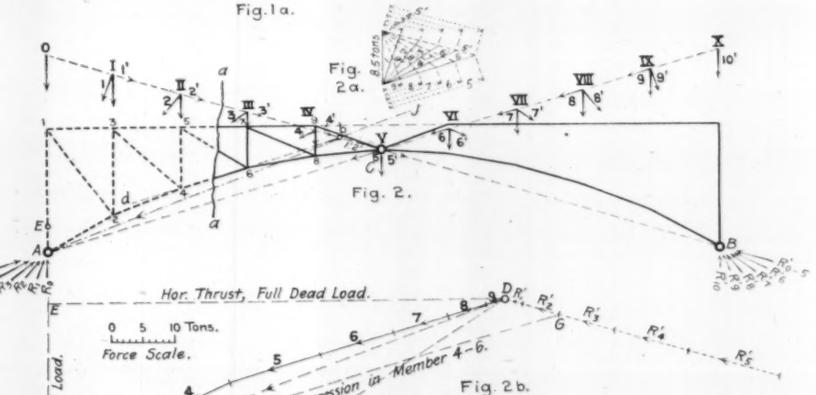

Fig. 2.

Fig. 2a.

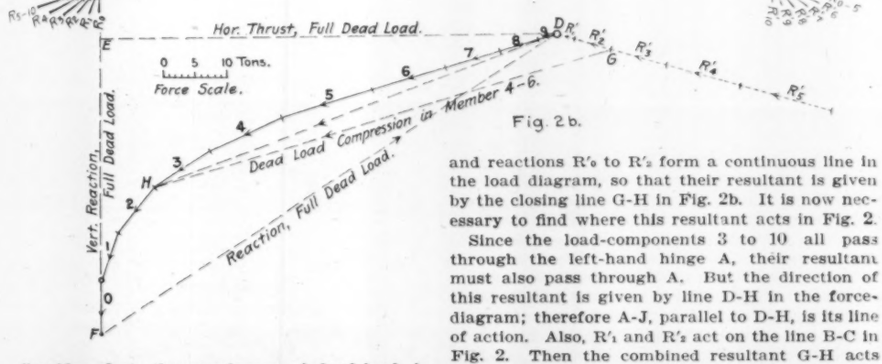

Fig. 2b.

Consider, first, the usual case of dead-load, i. e., the structure fully loaded with equal loads at all panel-points.

DEAD-LOAD STRESSES.

Fig. 2 shows the same arch, loaded at all panel-points with equal loads: 0, I, II, . . . X. Each load is resolved into its two components as was done with the single load of Fig. 1. One diagram, Fig. 2a, gives all the components. It is to be remembered that there is a reaction equal and opposite to each of these components.

In Fig. 2b these components are added graphically, by drawing the load-components 0 to 9 from F to D, parallel to their lines of action and equal to their values as found from Fig. 2a. Note that load-component 10 equals zero, since 10′ is vertical. Then it is obvious that the straight line F-D represents the left-hand reaction, in amount and direction; also that line E-D is the horizontal thrust. If the broken line F-D is followed from F towards D, it represents the various reactions at the left-hand hinge A. The right-hand half of the diagram Fig. 2b is symmetrical with the left half; but it is convenient to let the right half represent the right-hand reactions while the left half represents the left-hand load components. The arrows used in Fig. 2b correspond to this.

Now, to find the stress in any member, as in the bottom chord section 4-6, pass a section a-a to cut this member, and suppose the left-hand portion removed, so that the portion shown in full lines is to be considered as a free body. The forces acting on this body are:

1, the loads III to X, or their components, 3, 3′, to 10, 10′,

2, the reactions R′₀ to R′₁₀, and

3, the stresses in the members cut, 5-7, 5-6 and 4-6.

It will be seen that the load components 3′ to 10′ are balanced by the equal and opposite reactions R′₂ to R′₁₀, so that the only forces to be considered are: load components 3 to 10, reactions R′₀ to R′₂, and the unknown stresses. Referring to Fig. 2b, it appears that load components 3 to 10 and reactions R′₀ to R′₂ form a continuous line in the load diagram, so that their resultant is given by the closing line G-H in Fig. 2b. It is now necessary to find where this resultant acts in Fig. 2.

Since the load-components 3 to 10 all pass through the left-hand hinge A, their resultant must also pass through A. But the direction of this resultant is given by line D-H in the force-diagram; therefore A-J, parallel to D-H, is its line of action. Also, R′₁ and R′₂ act on the line B-C in Fig. 2. Then the combined resultant G-H acts at the intersection of A-J and B-C, that is, at the point b, and has a direction parallel to G-H, viz., b-d in Fig. 2.

The three unknown stresses are in equilibrium with the force G-H acting on the line b-d. But Fig. 2 shows that b-d coincides with member 4-6. Hence the stress in 4-6 equals G-H and is opposite in direction, that is, 4-6 is in compression. The stresses in 5-7 and in 5-6 are each zero.

It will be remembered that a parabolic line is the curve of equilibrium for uniform horizontal loading. A three-hinged arch whose lower chord is on a parabola passing through the hinges will therefore have no stress in the web-members, under uniform dead load. This checks with the result just found, that the dead-load stresses in 5-7 and 5-6 are zero.

The dead-load stresses in all the other members of the structure are found in exactly the same manner, and require no further explanation. One diagram, Fig. 2, suffices for all members, obviously.

The proper selection of the forces acting on the section in each case can be made by the following rule: "All load-components directed toward the section, whether belonging to the portion of the structure which was removed or on the portion retained, will be used in Fig. 2b to get the resultant. Those lying on the portion retained are used in their proper direction as load-components, those on the portion removed are used in opposite direction, as reactions."

The procedure for finding live-load stresses is precisely the same as just explained, only that for each member it must be preceded by the determination of the position of loading which gives maximum stress in that member. The method of accomplishing this latter purpose is well known. The following summary of the determination of typical live-load stresses therefore omits detailed explanation and gives only the successive steps in the procedure.

LIVE-LOAD STRESSES.

POSITION OF LOADS.—For members 5-7, 5-6 and 4-6, the section a-a (Fig. 3) is used, as before; the left-hand portion of the truss is supposed removed.

For member 5-7, the fulcrum is at panel-point 6. The "forces in the section"* for fully loaded bridge are 1′, 2′, 3, 4, 5, . . . 10; of these, 1′, 2′, 3 and 4 (1′ and 2′ being considered reversed) have a negative moment around 6; while 5, 6, 7, 8 and 9 have positive moment. Then the loadings for maximum and minimum stresses in 5-7 are:

5-7 { Max. compression, I to IV loaded.
Max. tension, V to IX loaded.

For member 5-6, the fulcrum is at d, Fig. 3. The forces 1′, 2′, 5, 6, . . . 9 have positive moment around d, while 3 and 4 have negative moment. Then the loading for 5-6 is:

5-6 { Max. tension, III and IV loaded.
Max. compression, remaining panel-points loaded.

For member 4-6 the fulcrum is at panel-point 5. Since 1′ and 2′ have negative moment while 3 to 9 have positive moment, the loading is:

4-6 { Max. tension, I and II loaded.
Max. compression, III to IX loaded.

As an example of stress in a vertical, we consider 4-5. The section for this purpose is on b-b, the fulcrum at d. The "forces in the section" are different from those for section a-a, being now 1′, and 2 to 9. Here 2, 3 and 4 have negative moment, while 1′, 5 to 9 have positive moment. Then the loading is:

4-5 { Max. tension, I, V, VI to IX loaded.
Max. compression, II, III, IV loaded.

STRESSES.—Stresses in 5-7. See Figs. 3 and 3a. I, II, III, IV are loaded and the forces in the section are 1′, 2′, 3, 4. Forces 3 and 4 have the resultant D-E, passing through hinge A, line A-J; forces 1′ and 2′ pass through hinges B-C. Hence the resultant acts at the intersection e of A-J and B-C. In Fig. 3a draw 1′ and 2′ to scale as line F-D; then F-E is the desired resultant in direction and amount, acting on line e-f in Fig. 3. The resultant e-f is in equilibrium with 5-7, 5-6 and 4-6. It intersects 5-7 at g, while 5-6 and 4-6 intersect at 6. Then the resultant of e-f and 5-7 acts on line g-6. Drawing F-G in Fig. 3a parallel to g-6 gives E-G as the maximum compression in 5-7.

For maximum tension, V to IX are loaded, and the forces are 5, 6, 7, 8, 9, whose resultant H-D in Fig. 3a passes through hinges A and C. Line A-C intersects 5-7 at h, and line h-6 is the resultant of H-D with 5-7. Then, H-K parallel to h-6 gives D-K as the maximum tension in 5-7. It will be observed that D-K = E-G, hence that with bridge fully loaded the stress in 5-7 is zero. This fact has been noted before, and checks the computation.

STRESS IN 5-6.—Maximum tension, III and IV loaded; forces in the section are 3 and 4. Their resultant (see Figs. 4 and 4a) is D-E, acting through hinge A, hence on line A-J parallel to D-E. A-J intersects 5-6 at k, while 5-7 and 4-6 intersect at d. Then d-k is the direction of the resultant of D-E with 5-6, and F-E parallel to d-k gives F-D as the maximum tension in 5-6.

For maximum compression, I, II, and V to IX are loaded, and the forces in the section are 1′,

*This term is used to denote the forces directed *toward* the section, as by the rule above given. In accordance with that rule, we will speak of 1′ and 2′ when R'_1 and R'_2 are meant.

2', 5, 6 to 9. Their resultant is G-D. Since 1' and 2' act on B-C in Fig. 4, and 5 to 9 act on A-C, the resultant passes through their intersection C and has the direction C-K parallel to G-D. C-K intersects 5-6 at m, while 4-6 and 5-7 intersect at d. Their joining line m-d is the direction of the resultant of G-D with stress 5-6; then G-F parallel to d-m gives D-F as the maximum compression in 5-6. As for the preceding member, the maximum liveload stresses are equal and opposite.

STRESS IN 4-6.—For maximum tension I and II are loaded and the forces in the section are 1' and 2', both of which act on line B-C. B-C intersects 4-6 (prolonged) at n (Fig. 5), while 5-7 and 5-6 intersect at 5; hence n-5 is the direction of their resultant. In Fig. 5a, E-D is the external force, and F-D parallel to n-5 is the resultant of this force with 4-6. Then F-E parallel to 4-6 gives the maximum tension in 4-6.

For maximum compression, III to IX are loaded, and the forces in the section are 3 to 9, all of which act through hinge A. Their resultant, D-G in Fig. 5a, must also act through hinge A, hence acts on line A-J, intersecting 4-6 (prolonged) at p. But 5-6 and 5-7 intersect at 5, so that p-5 is the direction of the resultant of D-G with 4-6. Drawing H-G parallel to p-5, and H-D parallel to 4-6, determines point H, which gives H-D as the maximum compression in 4-6.

For this member, of course, the live-load stresses are not equal and opposite, since the full load stress is not zero but equals line G-H in Fig. 2b.

The computation for a web-vertical, such as 4-5 is precisely similar to the above; it is to be remembered that in the web-verticals the full-load stress is not zero but equal to a panel load, so that the maximum live-load stresses must differ by that amount.

Attention may be called to the fact that for maximum stress in 8-10 the bridge is to be fully loaded; but for maximum stress in 9-10 the bridge is loaded on one-half only. In finding the live-load stress in 9-10, the resultant force on the section is to be resolved along 8-10 and 9-10. Since only two members are cut, the four-force method of resolution employed in the preceding does not apply, but the simple triangle of forces is sufficient.

SUGGESTIONS FOR APPLYING THE METHOD.

After making a diagram of the arch, to scale, lay off the curve of forces (F-D in Fig. 2b), by means of the diagram Fig. 2a. The curve of forces need be drawn only once, for both dead and live-load stresses. Make all subsequent computations on tracing-cloth, shifting it over the drawing so as to get a separate diagram for each member. Of course, all the work could be done on a single diagram, but the plan recommended will save confusion. Using a 6H pencil on the paper and an F pencil on tracing-cloth, and true straight edges and large triangles, will enable an astonishing degree of accuracy to be reached. The scale used should be not less than 1 in. = 6 ft., and 1 in. = 6 tons (or 1 in. = 10,000 lbs. when working in pounds), but may be larger, depending on the accuracy required.

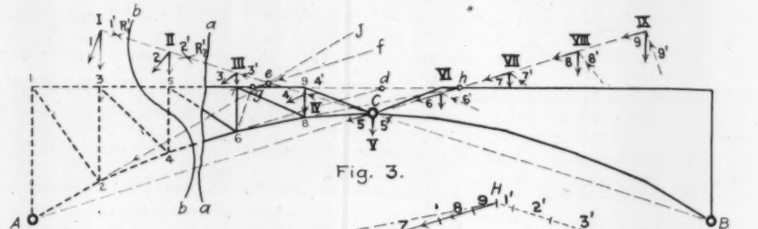
Fig. 3.

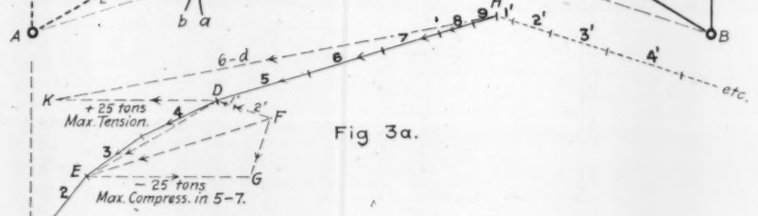

Fig 3a.

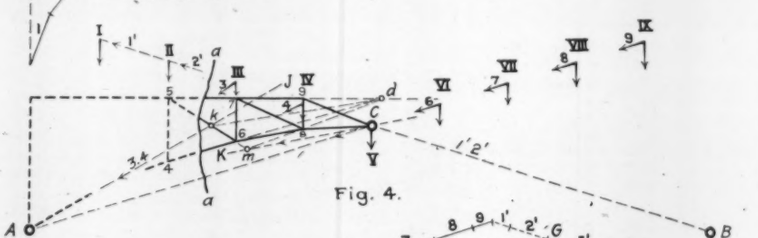
Fig. 4.

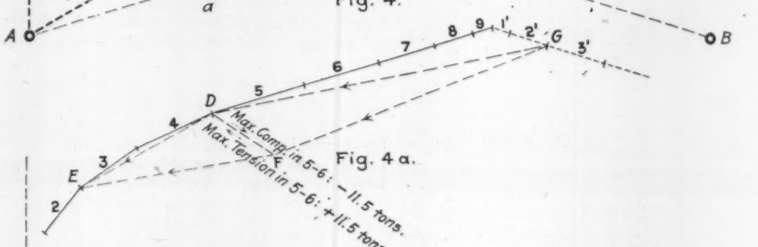

Fig. 4a.

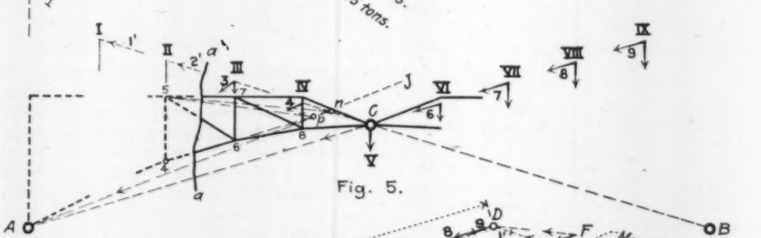
Fig. 5.

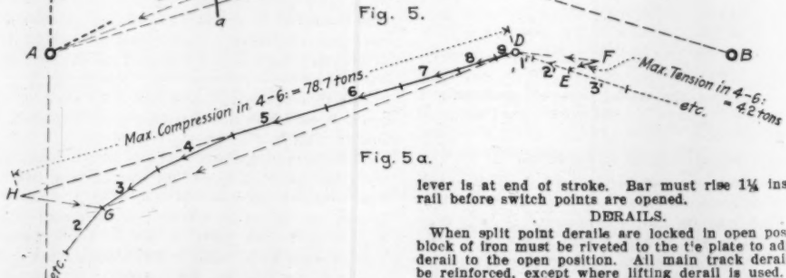

Fig. 5a.

STANDARD SPECIFICATIONS FOR MECHANICAL INTERLOCKING MATERIAL AND CONSTRUCTION WORK.*

MACHINE.

The machine must be the Saxby & Farmer improved.

The machine must be supported on a steel frame, not connected with the building in any way, except where the walls are built of fireproof material, in such cases the machine support may be built of I-beams or channel iron bedded into the wall.

Where practicable a spare bracket for cross locking must be provided for every section of four spaces in machine frame up to 16, and one spare bracket for each section of eight spaces over 16.

A spare space for longitudinal locking bar must be provided the entire length of the machine for each spare lever or lever spaces in the machine. All longitudinal locking must extend the entire length of the machine wherever possible.

All the levers in a machine must have an equal and uniform throw in the quadrant, and the throw in the lever tail for pipe must be not less than 8¾ ins., with an additional hole increased to 10¾ ins.

Where electric locking is used the machine must be provided with a mechanical screw hand release to release the locking in case the electric lock fails. The release must be made so it will take operator one minute to release. When derail lever has been released the home signal lever must be locked so operator will be compelled to return the release to its normal position in order to again lock the derail lever.

PIPE LINES.

Pipe lines must be used for connections to switches, detector bars, locks, selectors and home signals, if not otherwise specified, and may be used for all signals. The pipe must be 1 in. inside diameter, and weigh not less than 1.75 lbs. to the foot.

Pipe lines must be straight when possible, and must not be placed less than 5 ft. from outside rail, except where the line runs between tracks or on long ties, in which case the minimum distance shall be 3 ft. from nearest rail. Pipe lines must be laid 2½ ins. between centers, and must be supported on pipe carriers placed 7 ft. apart on straight lines, and 6 ft. apart around curves more than 6°.

Bends must not be made in pipe, but in jaws, or in iron rod 1¼ ins. diameter, placed in the pipe line for that purpose. The total bends must never exceed 2¼ ins. between any two supports. No bends must be made in cranks without special permission.

A compensator must be provided for each pipe line over 50 ft. in length and under 800 ft.; pipe lines over 800 ft. in length must have an additional compensator for each additional 800 ft. or fraction thereof.

Compensators must be built from an acute and an obtuse angle crank with arms 11 × 14 ins., centers mounted together on a cast-iron base 22 ins. centers. They must be made of wrought iron and not more than one compensator must be placed on one stand or foundation. Top of crank pins must be supported.

FACING POINT LOCKS.

Facing point locks must be used on all switches. Lock castings must be placed on outside of track and bolted to tie through an iron plate ⅝ × 6 ins. × 8 ft., placed on top of tie and securely fastened thereto.

Plungers must be 1 in. diameter and 20 ins. in length from center of pin hole to end, and must have a throw of 8 ins. Plungers must stand not more than 1 in. out of lock bar when switch is unlocked. The end must be square and not chamfered or pointed.

DETECTOR BARS.

A detector bar must be provided for each switch, movable point frog and torpedo and must work in connection with a facing point lock or switch and lock movement, and must also be used at crossings when necessary to insure clearance. If on a curve the bar must be placed along the outside rail.

Detector bars must be made of ⅝ × 2¼ ins. steel iron, not less than 50 ft. in length, and square corners. They must be bolted together in three pieces.

Detector bars must be placed on outside of rail and must work in a plane inclined toward center of track. Top of bar must stand ¼-in. below top of rail when lever is at end of stroke. Bar must rise 1¼ ins. above rail before switch points are opened.

DERAILS.

When split point derails are locked in open position, a block of iron must be riveted to the tie plate to adjust the derail to the open position. All main track derails must be reinforced, except where lifting derail is used.

ADJUSTMENTS.

Means of adjustment must be provided for each line of pipe and wire. All adjusting screws must be open.

Switches, derails, movable frogs and all pipe connected signals must be provided with adjustment to regulate the throw.

Derails must be open not less than 4 ins. Lifting derails must open 5 ins. Switches and movable point frogs must open 5 ins.

BOLT LOCKS.

All facing point switches, derails, movable point frogs on main track must be bolt locked with signals governing that route, and in all cases where switch and lock movements are used bolt locks must also be used. Distant signals will not be bolt locked.

SIGNALS.

All signal poles must be of lap welded iron pipe, of trolley pole pattern, with swedged joints made in sections of 4, 5 and 6-in. pipe. A one-armed pole must be 32 ft. long and weigh not less than 550 lbs. without fittings; a two-armed pole must be 38 ft. long and weigh not l

*Extracts from a set of specifications submitted at the annual convention of the Railway Signal Association, at St. Louis, Mo., Oct. 12.

than 650 lbs. without fittings. Poles must be set in concrete 5 ft. deep and 2 ft. square.

Signal arms may be carried on straight poles, bracket poles or bridges.

On bracket poles the bracket must be not less than 23 ft. above top rail. Bridges must be not less than 23 ft. in the clear above top rail. Single arms on high poles must not be less than 25 ft. above top of rail. When two arms are placed on the same high pole, lower arm must be not less than 25 ft. above top of rail. Dwarf signal arms must be not less than 2½ ft. above rail.

Semaphore arms on the same single high pole must be placed 6½ ft. c. to c.

High signal arms must be made of ash. Dwarf signal arms must be made of rubber or a ground enamel disk combination light casting and blade.

All arm plates must hold three glasses, 6½ ins. diameter and ¼-in. thick. The back light must be 3 ins. diameter. Dwarf signals must hold two glasses same size as above and same size of back light.

Home and distant signals must be 8 ft. from outside of rail to face of pole. Dwarf signals must be not less than 4 ft. from nearest rail to center of signal. If high signal is placed between tracks there must be not less than 6 ft. from outside of rail to face of pole or up and down connection.

COUNTERWEIGHTS.

All signals must be provided with counterweights, to compel arm to go to horizontal position should a break occur in any connection. Where signal poles are between tracks the counterbalance lever must be set parallel with the tracks.

Disengaging lever must be used on all wire connected distant signals.

Counterweights must incline downward at an angle of 45° to center line of arm when arm is in horizontal position.

WIRE.

Signal wires shall be No. 9 gage. Wires shall be well and evenly galvanized and close wiped, so that in bending the galvanizing will not crack off.

Where signals are wire connected, both front and back wires must be used, and the back wire must have 1½ ins. more stroke than the front wire.

Where front and back wires are used a counterbalance lever must be used for each arm, and the up and down rods to all signals must be so connected that the arm will be pushed to the clear position.

Wire lines must be placed 7 ft. from outside of rail, except where carried on foundations. They must be carried on pulleys placed not more than 21 ft. c. to c. Wire carriers must be placed on stakes, except where they can conveniently be placed on pipe carrier foundations.

Where wire lines lead around curves the carriers must be inclined at an angle of 75° to the vertical.

Turns in wire lines must be made around wheels with ¼-in. chain.

Chain wheels must be 10 ins. diameter in all places on main wire line, except lead-out wheels and wheels on dwarf and bracket poles which may be 6 ins. diameter.

Sheaves or wheels must not be less than 2 ins. at smallest diameter.

Wire compensators must be provided for all wire lines over 600 ft. in length.

FOUNDATIONS.

Pipe carrier foundations must be of concrete, and have top of best white oak 3 × 8 ins. The top must be fastened by two ½ × 10-in. hook bolts connected to cast-iron anchor shoe set in the foundation.

All crank and wheel foundations must be of concrete, 3 × 3 × 3 ft.

All compensators and dwarf signal foundations must be concrete 3 ft. in depth, 2½ ft. in width and 4 ft. in length.

All cranks, compensators and wheels must be fastened to an iron pier set in concrete, arranged with slot to hold ¾-in. bolts. Plank to hold dwarf signals and deflecting bars to be fastened in a similar manner.

Iron bracket poles must be concreted 4 ft. in width, 4 ft. in length and 5 ft. in depth.

Wood top shall be used only on pipe carrier and dwarf signal foundations. Top for dwarf signal foundations to be 4 × 12 ins., best white oak.

All foundations must be concreted in such manner that bolts can be taken out of plank and apparatus at any time without injuring and disturbing foundation.

Crank and wheel foundations must be set so that center line of foundations will bisect angle made by connection.

All stakes must be not less than 3 × 4 ins., 4 ft. long, with 7-in. point.

CONCRETE.

All sand must be clean, sharp bank sand, free from loam and vegetable matter.

Broken stone or gravel screenings used must be not larger than will pass through 2-in. ring.

Artificial Portland cement shall be used, of best quality.

The stone and gravel used must be perfectly clean and must be wet before mixing with mortar. Mortar and stone or gravel must be thoroughly mixed and used immediately after mixing. The mixture should be thoroughly wet and damped as much as possible. For mortar to be used in freezing weather add 1 lb. of salt to each four gallons of water used in mixing; but contractors must take all risks in mixing concrete in freezing weather.

All foundations must stand at least ten days after concrete work is done before being connected to apparatus.

PAINTING.

The levers must be painted three coats, as follows: Switch levers, black; movable crossing levers, lemon yellow; lock lever, light blue; home signal levers, vermilion; distant signal levers, lawn green.

When a lever is used for more than one purpose it must be painted to correspond with colors used on separate levers for same purposes.

Signal arms must be painted one coat of priming and two finishing coats.

Signal poles must be painted one coat of graphite for first coat and two coats white and black for finishing coat. Under no circumstances must signal poles or any other iron work be painted or dipped in tar or asphaltum.

All iron work, except detector bars, tie plates and iron foundations must be painted two coats of graphite paint.

All chain and other iron work, not machine finished, must be dipped in graphite paint before being shipped.

The ends of all pipe must be dipped 1 ft. in graphite paint before being shipped.

All boxing must be painted one coat of metallic oxide paint.

Boxing, when it is required, must be made of good pine lumber, surfaced on one side. Planks 2 × 8 ins. must be used for the sides and tops, and, if necessary, 1 in. rough stuff for the bottom. Boxing will be required at road crossings and streets and over lead-out, switch and lock movements and selectors. All pipe and wire lines must be boxed for 6 ft. from rails where they cross tracks. When required, highway crossings must be boxed with 4-in. oak for top and sides. Where wires cross highway they must run in ¾-in. galvanized pipe provided with a stuffing box in each end, pipe to be filled with black oil.

NOTES ON TESTS FOR WOOD PAVING BLOCKS.

A large part of the recent revival of wood blocks as a paving material in this country has been due to the efforts of a company engaged in treating and laying wood blocks. At every meeting of the American Society of Municipal Improvements for the last four years there has been presented a paper by Mr. F. A. Kummer, Assoc. M. Am. Soc. C. E., one of the leading officers of that company. At St. Louis, two weeks ago, Mr. Kummer presented a paper entitled "Notes on Tests for Wood Paving Blocks."

After speaking of the comparative newness of wood paving block tests and the desirability of such tests, and mentioning the fact that he is a member of the Committee on Standard Tests for Road Materials of the American Society for Testing Materials, Mr. Kummer offered some suggestions regarding the lines to be followed in testing wood blocks.

Assuming that proper lumber is specified and used and that the blocks are subjected to some process of treatment, the further questions relate chiefly to whether or not the process is a good one and if good, whether it is properly carried out. The quality of lumber being used can be easily determined either before or after the blocks are treated. The thoroughness of the treatment may be determined by inspection during or by tests made after the treatment. In the latter case, and assuming that thorough impregnation with the treating material is required, the blocks may be split to see whether the penetration extends to the center; or the blocks may be placed in water to see whether they will sink, "it being a well-known fact that blocks thoroughly treated throughout with creosote or a creosote mixture will sink in water."

The author next quoted with approval the following specifications for wood paving block prepared by Mr. Geo. W. Tillson, M. Am. Soc. C. E., for use in Brooklyn:

(1) The wearing surface shall be composed of long leaf, all heart, yellow pine blocks, treated as hereinafter described. All blocks shall be of sound timber, free from bark, sapwood, loose or rotten knots, or other defects which shall be detrimental to the life of the block or interfere with its laying. No second-growth timber will be allowed.

(2) The blocks are to be treated throughout with an antiseptic and waterproof mixture, at least 50% of which shall be dead oil of coal tar, commonly known as creosote oil. The remainder to be resin or some other similar and suitable waterproof material. All portions of each individual block shall be thoroughly treated with the mixture, and after treatment the specific gravity of the blocks shall be greater than that of water.

(3) After treatment the blocks shall show such waterproof qualities that, after being dried in an oven at a temperature of 100° for a period of 24 hours, weighed, and then immersed in clear water for a period of 24 hours and weighed, the gain in weight shall not be greater than 3%.

The four physical tests required by the specification (quality of lumber, absorption, thorough treatment and specific gravity), Mr. Kummer says, "cover almost all, but not quite, the entire ground." An important item omitted is the "hardening of the wood." He then indicates the advantages of rosin over such a water-proofing material as paraffin or bitumen, in point of the hardness added by the rosin. From this the author proceeds to discuss the possibility of a test for hardness which shall be for wood what the abrasion test is for brick. Tests with a Doré machine, at Washington, were to have been included in the paper but an accident to the machine made that impossible. The Doré machine is used in the laboratory for testing road materials at Washington. It

consists roughly of a horizontal plate revolving against the face of the block to be tested under given pressure, sand being fed upon the plate so as to produce a uniform and regular abrasion of the surface of the test piece.

The use of this machine for testing wood blocks was suggested by Mr. Logan W. Page.

THE SEWAGE TESTING STATION AT COLUMBUS, O.

By John H. Gregory,* Assoc. M. Am. Soc. C. E.

At the general election held last November, the people of the City of Columbus, O., voted the expenditure of $1,200,000 for the purpose of constructing a sewage disposal plant, and of making the necessary improvements and extensions to the sewerage system thereby required, this being the first of a series of important municipal improvements which it is planned to carry out. This work, in connection with the high concrete masonry dam across the Scioto River, and the large storage reservoir, six miles long, both of which are now under construction, and the proposed water softening and purification works, will place Columbus in the first rank among cities striving for improved sanitary conditions.

The problem of disposing of the sewage of the city was placed in the hands of the board of public service, and is under the immediate direction of Mr. Julian Griggs, Chief Engineer. Messrs. Rudolph Hering and Geo. W. Fuller were appointed consulting engineers. The writer was appointed engineer of design, later being made principal assistant engineer. Still later Mr. Geo. A. Johnson was appointed engineer in charge of the sewage testing station, the construction of which it is the purpose of this article to describe.

To review briefly the steps that had been taken previous to the voting of the bond issue, it may be said that Mr. Griggs and Mr. John Alvord made a careful and exhaustive study of the problem and presented a joint report in 1898, in which they recommended double filtration through coke breeze filters. No immediate action was taken after the submission of this report, and in 1901 Mr. Hering was asked to review the whole subject. In the report submitted by him, he recommended the installation of septic tanks followed by intermittent filtration through sand, with the additional recommendation that only a part of the plant be constructed at first, and that it be operated for a period of at least one year for the purpose of determining the most efficient and economical arrangement of the remaining part of the plant.

The engineers, in whose hands the carrying out of the work was placed, were thus confronted with the problem of designing a plant, a portion of which was to be used for experimental purposes and later to be made a part of the permanent works. On mature consideration of the subject it was considered advisable, before embarking on the expenditure of such a large sum of money, to ascertain exactly, by a series of extended experiments on a practical scale carried on for a period of one year, the most efficient and economical method of disposing of the sewage of the city. The cooperation of the board of public service and of the city council was asked, and they very generously responded by appropriating the sum of $46,000 for this purpose. A sewage testing station was, therefore, built, in accordance with recommendations made by Messrs. Hering & Fuller. The station is now in full operation and the construction of the permanent works will be based upon the results obtained during the year's test.

The testing station, a general plan of which is shown by Fig. 1, is situated about two miles south of the center of the city on a piece of property especially chosen and purchased for the purpose. Under a corner of this property the main intercepting sewer is located, and it is estimated that about three-fourths of the total dry weather flow of the city passes this point. It is believed that the sewage pumped from this sewer for experimental purposes represents quite accurately that which the disposal works will have to handle.

The station consists of a pump chamber in the intercepting sewer, a pump house, screen chamber, two grit chambers, one plain settling tank, two chemical precipitation tanks, two septic tanks, two intermediate settling tanks, two primary contact beds of broken stone, four secondary contact beds of coke, two coke strainers, four sprinkling filters of broken stone, 21 intermittent sand filters, one reserve filter and a laboratory. It may be mentioned that the amount of sewage which is treated by the above experimental devices is about 350,000 gallons per 24 hours.

The pump chamber (Fig. 2) is built in the intercepting sewer, at the bottom of an existing manhole, as shown in one of the details, and is of

*Principal Assistant Engineer, Board of Public Service, Columbus, O.

timber construction, with one side open; this open side, however, being protected by a galvanized iron screen made of wire 0.10-in. in diameter and having a ¼-in. clear mesh. In this chamber is located a 4-in. centrifugal pump of the vertical submerged type. The chamber was arranged with the open side, through which the sewage passes to the pump, parallel to the center line of the sewer, so that the flow of sewage past the chamber would keep the screen clean. The pump shaft is extended up above the surface of the ground and is connected by a belt and pulleys with a horizontal 500-volt direct current shunt wound motor, located in a pump house of frame construction. The current for operating the motor is obtained from the street railway company.

The pump, which has a capacity of from 300,000 to 700,000 gallons per 24 hours, raises the sewage against a head of from 30 to 33 ft., depending on the amount pumped, through a 6-in. wrought iron pipe into the screen chamber. This chamber is built of yellow pine lumber, is 4 ft. 10 ins. long, 2 ft. 6 ins. wide and 3 ft. deep, and is fitted with a double set of vertical screens. From the screen chamber the sewage passes into the east side of either or both of the grit chambers, as may be desired. After passing through the grit chambers the sewage passes out from the west side to the plain settling, chemical precipitation and septic tanks and to the east gallery, and a portion of it also goes to certain devices in the north and south galleries.

The grit chambers, plain settling, chemical precipitation and septic tanks, seven in number in all, are rectangular in plan, 40 ft. long, 8 ft. wide, 8 ft. deep at one end and 9 ft. deep at the other. The tanks are built of yellow pine lumber, the insides and bottoms being of 2-in. tongued and grooved plank, and all are lined with No. 26 galvanized sheet iron, the sheets being soldered together at the joints. The bottom of each tank has a slope of 1 ft. in 40 to facilitate the removal of sludge. Each tank has two outlets at the low end connecting with the 8-in. vitrified drain running to the storm water sewer in Moler St., one outlet being flush with, and the other 2 ft. above, the bottom of the tank. All the tanks are open, but they are banked up with earth around the outside. The construction of the tanks and the arrangement of the piping is shown in one of the accompanying figures.

The north gallery, so-called from its location, certain details of which are shown, contains 18 circular tanks charged with different kinds of filtering material. The tanks are arranged in two rows of nine each, and between the rows is a gallery containing the pipes and measuring appliances. This gallery is covered by a light frame building to protect the pipes and measuring apparatus from the elements, and during the winter will be heated sufficiently to prevent freezing.

These tanks are built of 1¼-in. cypress, are 6 ft. deep, 7 ft. 5⅜ ins. in diameter, and each has a filtering area of 0.001 of an acre. The tanks are open, but are banked up with dirt on the outside to prevent lateral freezing of the filtering material during the winter, so as to correspond as nearly as possible with conditions which would occur with works constructed on a large scale.

The apparatus for controlling the rate of flow through certain of the rectangular tanks, and which is also used for closing the various devices, is located in this gallery. The apparatus consists of an orifice box for each of these rectangular tanks, built of cypress and fitted with a rectangular brass orifice, 1½ ins. high and having a width adjustable up to a maximum of 4 ins. A constant head of 1 ft. is maintained on the orifice by throttling the gate valve on the inlet. A detail of one of the orifice boxes is shown by Fig. 3.

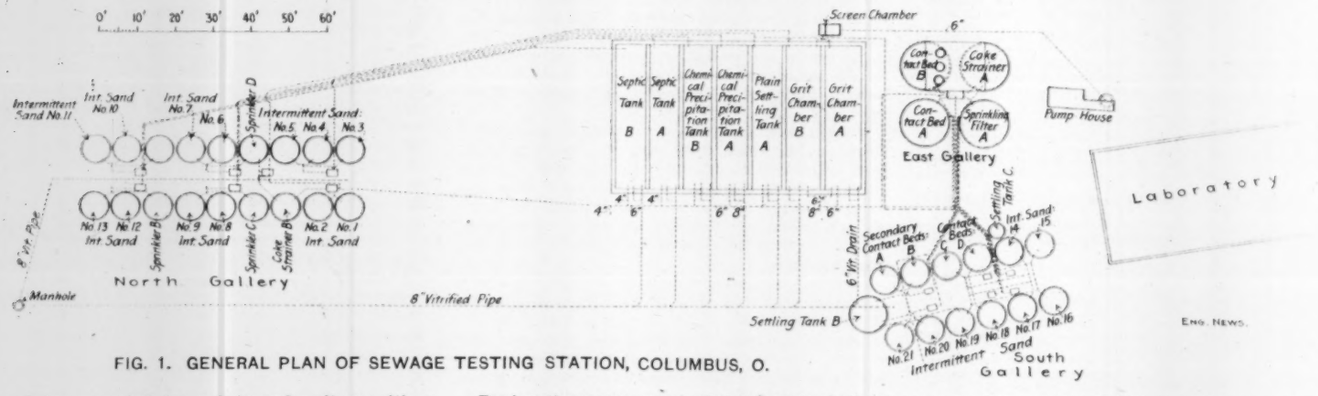

FIG. 1. GENERAL PLAN OF SEWAGE TESTING STATION, COLUMBUS, O.

During the greater part of the day the bulk of the flow from the rectangular tanks is wasted into an 8-in. vitrified drain extending the full length of the gallery and connected with the sewer in Moler St. When it is necessary to dose one of the circular tanks, the waste to the drain is shut off and the full flow from the rectangular tank is turned into the circular tank for a length of time sufficient to give the desired dose. The effluent from each of the circular tanks passes out through a so-called measuring box and thence to the 8-in. drain. The measuring box serves to store the effluent for a short period of time so as to secure representative samples.

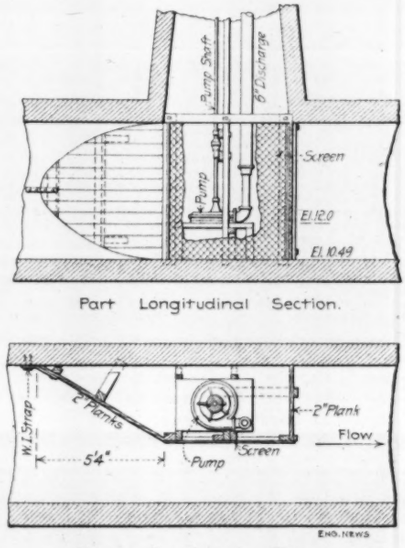

Fig. 2. Arrangement of Sewage Pump and Screen in Intercepting Sewer.

The east gallery is, in a general way, similar to the north gallery, but contains only four tanks. These tanks are built of 1¾-in. cypress, are 6 ft. deep, 12 ft. 10¾ ins. in diameter and each has a filtering area of 0.003 of an acre. Dirt is banked up around the outside of these tanks, but they are, however, entirely covered over by a light frame building, which will be heated during the winter.

The tanks in this gallery all receive sewage direct from the grit chambers through a 6-in. wrought iron pipe. This pipe discharges into the center of the gallery into the central compartment of a large orifice box, which is fitted with four adjustable brass orifices similar to those in the individual orifice boxes in the north gallery, but having a height of 1 in. instead of 1½ ins. The flow to the large tanks is controlled by these orifices. On two of the sides of the central compartment of this orifice box, weirs are provided with their crests 1 ft. above the center of the orifices. This box is so set that the crests of these weirs are at the same elevation as the flow line in the grit chambers, the friction in the 6-in. pipe being negligible, and serves as an overflow for the grit chambers in case the pump discharges more sewage into the grit chambers than the various devices throughout the station are set to handle.

The effluents from two of the tanks in the east gallery discharge direct, and those from the other two through the intermediate settling tanks B and C, into the secondary devices in the south gallery.

In the east gallery are located also the tanks in which the chemical solutions of alum, lime and iron are mixed. These are three in number, 3 ft. in diameter, 3 ft. deep and built of 1¼-in. cypress. The solution from each of these chemical tanks flows out into a small cypress ball-cock tank in which a constant level is maintained by a float and ball-cock. The ball-cock tanks discharge into pipes running to the chemical precipitation tanks, the rate of flow of the solution from each being controlled by throttling the valve on the discharge.

The south gallery, the details of which are not shown, is very similar to the north gallery, the main difference being in a more complicated arrangement of the piping. This gallery contains twelve circular tanks of the same size as those in the north gallery, the dosing of the tanks being controlled by orifice boxes and the effluents passing out through measuring boxes to a central drain in the same manner as in the north gallery.

For a better understanding of the way the various devices are at present connected up, the following outline will be of service. The arrangement of the piping is such, however, that several other combinations are possible:

Grit Chamber in each case to:
- Intermittent Sand Filters 1 and 2.
- Plain Settling Tank A, thence to Intermittent Sand Filters 3, 4 and 5.
- Chemical Precipitation Tank A, thence to Intermittent Sand Filters 6 and 7.
- Chemical Precipitation Tank B, thence to Intermittent Sand Filters 8 and 9.
- Septic Tank A, thence to Intermittent Sand Filters 10 and 11.
- Septic Tank B, thence to Intermittent Sand Filters 12 and 13.
- Contact Bed A, thence to Settling Basin B, thence to Intermittent Sand Filters 19, 20 and 21.
- Contact Bed B, thence to Secondary Contact Beds A and
- Sprinkling Filter A, thence to Settling Basin C, thence to Intermittent Sand Filters 16, 17 and 18.
- Sprinkling Filter B.
- Plain Settling Tank A, thence to Sprinkling Filters C and D.
- Coke Strainer A, thence to Intermittent Sand Filters 14 and 15.
- Coke Strainer A, thence to Contact Beds C and D.
- Coke Strainer B.

With the exception of the vitrified drains which extends from the storm water sewer in Moler St. to the north and south galleries, the pipes are all of wrought iron. In the ground and on the inlet pipes to the orifice boxes, gate valves are used, but on all other pipes through which sewage flows, iron cocks with brass plugs and lever handles are used to facilitate dosing and draining and also to show at a glance whether a line is opened or closed.

The laboratory, in which the chemical and bacterial analyses are made, shown in plan and cross-section by Fig. 5, is of frame construction, and contains the main office, an office for the attendants, a chemical laboratory, bacteriological laboratory, preparation room, store room, work shop and toilet. An ice-chest having three compartments, with doors opening out into the bacterial laboratory and into the preparation room, is built in, arranged especially to facilitate the handling of samples.

The laboratory and galleries are all lighted and heated by natural gas, and on account of the frame construction, fire plugs with hose and nozzle attached have been placed in each, ready for instant use in case of necessity.

The testing station was designed by the writer, in accordance with the schedule of experimental devices recommended by Messrs. Hering & Fuller. The work was built under the immediate supervision of Mr. E. A. Kemmler, Assistant Engineer. The operation of the station is under the direct supervision of Mr. Geo. A. Johnson, as engineer in charge, with Mr. A. Elliott Kimberly as chemist, Mr. William R. Copeland as bacteriologist, and Mr. Geo. P. Shute as assistant engineer.

SOME GEOLOGIC PRINCIPLES OF SUBTERRANEAN WATER SUPPLY.

By F. J. H. Merrill.*

The principles of surface water supply have been carefully studied and formulated and the study of runoff, by the gaging of streams, is widely in progress to make complete records for future use. The details of subterranean flow have not yet been classified with the same degree of accuracy, and, from time to time, in the progress of important undertakings, the geologist is called on to aid the engineer with such guidance as he can supply.

From the geologic point of view, sources of underground water may, for convenience, be grouped in the following scheme of classification.

Surface Wells.		
Deep wells in soft rocks.	Sand or gravel over clays.	
	Sand or gravel in hard rock basins.	
Deep wells in hard rocks.	Structural.	In porous rocks over impervious strata.
	Accidental.	In impervious rocks through joints or bedding planes.
		Underground drainage in limestone.

Under the name of surface wells, may be considered the very large class of ordinary wells which are usually less than 50 ft. in depth and draw their supply directly from accumulations of surface water in some porous superficial deposit. No special geologic principles are involved in these and the quantity of the water is a matter of chance, while its quality is often seriously affected by surface pollution.

Adjusting our discussion of deep wells to the classification suggested, we may consider first the soft rocks yielding water. These afford the simplest problems. When a sufficiently large exposure of sand or gravel forms a drainage area, a large percentage of the rainfall will penetrate this loose material and sink through it until it reaches some impervious stratum, such as a bed of clay or the surface of some hard bed rock. On this impervious formation the water will stop in its downward course and, with a flow proportioned to its head and the friction in the porous stratum, will rise toward the surface if a well is bored or seek an outlet laterally if circumstances permit. For example, the subterranean water of Long Island, arrested by beds of clay which slope southward, moves slowly toward the ocean.

Where the porous stratum receives water only on its outcrop and is included between gently sloping impervious formations, such as clay or marl, the water supply may be conducted a long distance, and may yield flowing wells. These conditions prevail in Southern New Jersey and are productive of abundant artesian supplies for the various coast resorts.

Again, a mass of porous material may be deposited in a depression or basin of an impervious bed rock. Here the water naturally seeks an overflow at the lowest point of the rim of the basin. A good example of this is seen in the water supply obtained from wells near Silver Lake, Staten Island. There a large cavity or depression in the impervious, unstratified serpentine has formed a subterranean reservoir, which has been tapped by numerous wells and used for municipal supply.

In hard rocks, the more attractive and reliable conditions are found, when a porous rock, such as sandstone, overlies an impervious rock, such as

*Consulting Geologist, 20 East 42d St., New York City.

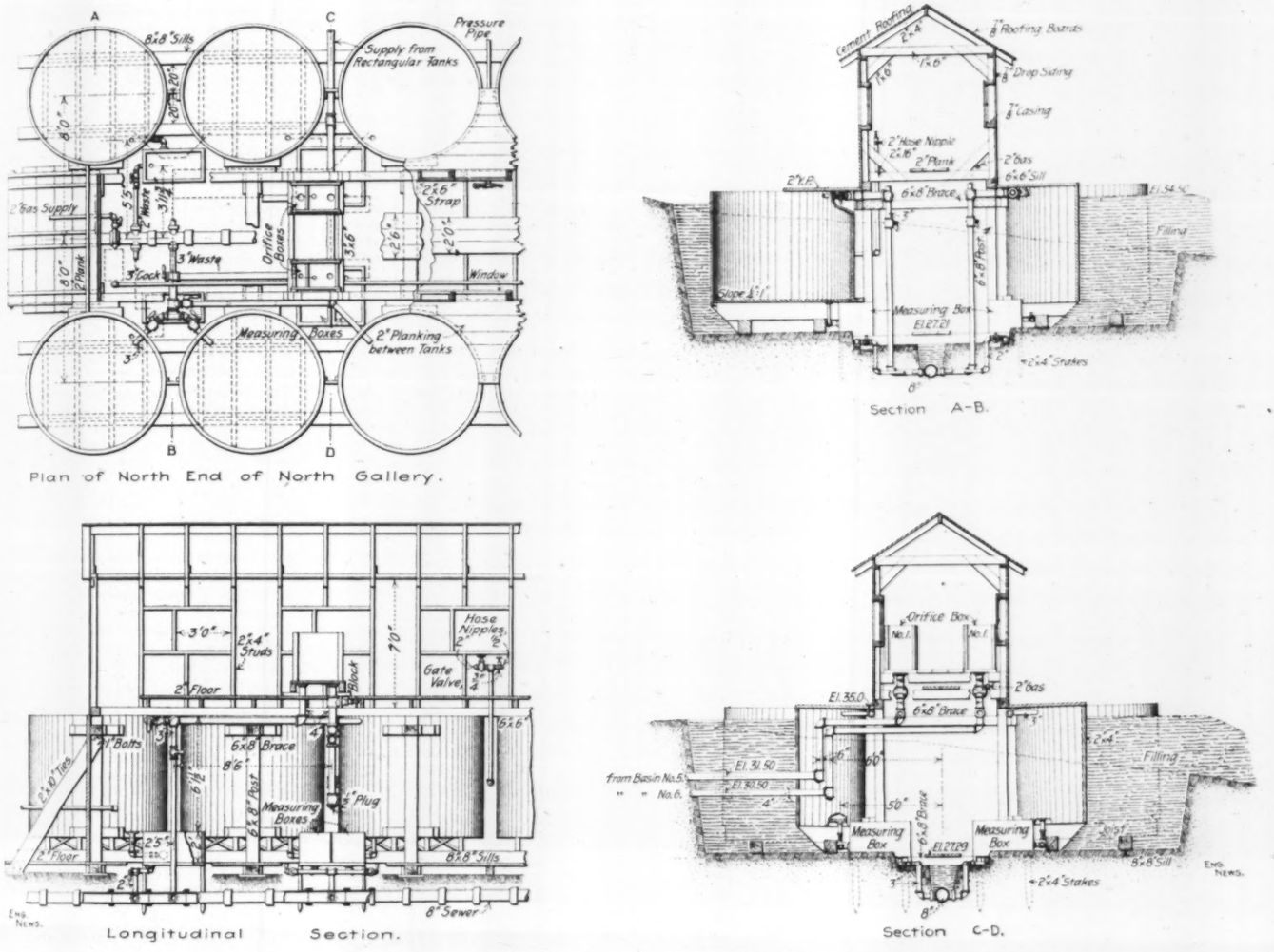

FIG. 3. PARTIAL PLAN AND SECTIONS OF NORTH GALLERY OF COLUMBUS SEWAGE TESTING STATION.

shale. Here the joints of the sandstone, as well as its bedding planes, afford channels of flow and areas of storage in addition to the minute cavities due to porosity. Here water should be found and, if the porous rock has an impervious cover and the higher portion underlying the impervious stratum bears such a relation to the mouth of the well as to cause sufficient hydrostatic pressure, a flowing well will result. That of Grenelle at Paris is an historic example of this type.

Storage of water in hard rocks must be called accidental, when the latter are of an impervious character like shale or slate, and when the flow of

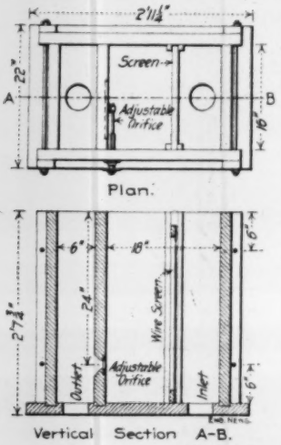

Fig. 4. Orifice Box Used At Columbus Sewage Testing Station.

the water occurs through joints and fractures. Such flow is extremely uncertain and an illustration of the absence of water from such rocks is seen in the case of the Altamont gas well in Albany County, N. Y., which was sunk 2,800 ft. without yielding enough water to supply the boiler for drilling.

The solubility of limestone in atmospheric waters makes it a ready field for the development of subterranean streams which, in some cases, attain large dimensions and form pools and lakes. Where such bodies of water are known to exist they may be made a source of water supply, but the possibility of reaching them by boring from the surface, without prior knowledge of their existence, is wholly a matter of chance.

Massive eruptive rocks, such as granites, are often entirely free from water. Sometimes, through joints, as above stated, water may be admitted. Shales and slates as before described may be unfruitful in water supply. Even rocks which normally contain water may be drained by deep gorges in the immediate vicinity. Sometimes these gorges are filled and concealed by loose material and are only to be found by careful search.

In many areas, notably in Southeastern New York and in Connecticut, the rock strata have been tilted to a vertical position. In this case the planes of bedding or schistosity have at many points been opened by faulting, so that they afford passage to surface water which also finds its way through many joints or fault planes separate from those of the bedding. Wells bored in such strata are likely to yield a water supply satisfactory in quantity though not in quality. This is due to the fact that the water comes directly from the surface in the immediate vicinity of the well and that the character of the rock is not such that it operates as a filter. In rural districts where obvious sources of pollution may be excluded, the problem is not so difficult, but in New York City, the water from artesian wells is usually much polluted. An exception to this rule was the case of the deep well at the Grand Union Hotel, which for a long time yielded water fit for certain uses. After the dynamite explosion in the subway under Park Ave., the quality of the water changed, possibly through the opening of some new channel, and the supply has since been unfit for use.

Not all wells in these tilted rocks yield water. At many points such rocks are injected with igneous granites which, being impervious, may serve to cut off the flow from adjacent areas.

One of the more attractive features of artesian wells in loose deposits is that they usually furnish a supply of pure water.

INDUSTRIAL LEGISLATION IN AUSTRALIA.

The industrial legislation now in force in several of the States of Australia, is an interesting social experiment. The results are worthy of note, though a sufficient time has not yet elapsed to permit the full effect to be measured.* The financial crisis of 1903 was accompanied by strikes and serious labor troubles, the workingman battling against a reduction in wages, the labor element finally gained the ascendency in the government and laws have been passed especially intended to favor the contentions of the labor unions. From 1896 to 1901 the movement in wages has been distinctly upward, though the amount of daily wage now received is still far from the demands of similar unions in the United States. In Sydney, for example, the per day pay of a carpenter has risen from $1.92 to $2.40, and a similar rise is noted in other trades. The new Factory Act of 1896, now applies to any place where four persons are employed; it gives power of prosecution to inspectors when a workroom is found to be in an unsanitary condition; no child under 13 years can be employed in a factory; it fixes the hours of opening and closing the shop; and all articles made outside of a registered shop must be conspicuously labelled when put on sale, showing that the work was done in places liable to disease.

New South Wales, in 1899, passed an Early Closing Act, providing for compulsory closing of shops at 6 p. m. on four days in the week, 1 p. m. on one day, and at 10 p. m. on one day. South Australia and Queensland have passed similar acts.

The Conciliation and Arbitration Bills, passed by several of the Colonies, take in as parties to the agreement (1) trades unions, (2) industrial unions, (3) industrial associations, (4) employers. Every industrial agreement is to be valid for a special time not exceeding three years, and must be filed with the Supreme Court. It is binding on both sides; but the penalty of failure to keep the agreement does not exceed $2,500, unless another amount is fixed in the agreement. The Board of Conciliation is chosen by "industrial unions of employers and of workmen" in the "industrial districts" formed; and should the board fail to agree, it can refer the question to a Court of Arbitration appointed for the whole State. In this court of three members, one is a Judge of the Supreme Court, one is appointed by the council of the association of employers, and one by the similar council of the workingman. But the amount of any award against either association is limited to $2,500. Other laws of a similar nature are in force.

As might be expected, this novel legislation did not work very smoothly to begin with, and numerous amending acts have since been passed. The amendments generally extend the powers of the tribunals of arbitration, and carry the principle of compulsion further than contemplated originally. In certain cases, non-union workmen and clerical employees are brought within the jurisdiction of the Arbitration Court. The several States have modified their laws according to local demands; and in New South Wales any employer or association of employers employing 50 or more persons, may register as an industrial union. But employees must first register as trade unionists, and can only thus become industrial unions under the Act. And no one other than such an industrial union can enjoy any of the benefits of the Act; and the law thus fosters the organization of both employers and workingmen.

An old-age pension system is in operation at the present time in New South Wales, Victoria and New Zealand, the first act of this nature having passed in 1898. In New Zealand every person of the full age of 65 years or upwards is eligible for a pension, provided he has resided continually in the Colony for 25 years. But he must not possess an annual income in excess of £250, nor property exceeding $1,200 in value; other qualifications affect good citizenship. The full pension is $100 per year, payable monthly; but this is liable to pro rata reduction for any other income over $167 per year. About 35% of the population over 65 years old is eligible for pensions. In New South Wales the annual pension is $126; and in Victoria, only those are entitled to a pension whose average weekly income has not exceeded 8s. or $1.94 for six months preceding their application. The rate of pension is fixed for each individual case by the Treasurer of the Colony. The basis of this old-age pension scheme is declared to be the fact that these citizens contributed by taxation and during the prime of life helped to bear the burdens of the State by their labor and skill. At the beginning of 1904, 156,200 persons in Australasia and 33,500 persons in New Zealand were figured as having reached 65 years of age; of this total number, probably 87% have resided in Australasia for the required 25 years. If a federal pension scheme were in force, there would be almost 67,000 pensioners, costing $7,620,000 per annum at the New South Wales rate. No comment is made on the working of the old-age pension system. Nor does the text of this work discuss the general working of the labor legislation referred to; but it is stated that the effect of these laws in Victoria has been to increase the pay of male labor about 19%, and that of female labor 17%, as compared with rates of similar labor before the passage of the act.

*The information given in this article is based on statements in "A Statistical Account of Australia and New Zealand, 1902-3," by T. A. Coghlan (Sydney, New South Wales: Government of the State of New South Wales and Commonwealth of Australia).

THE LEIPZIG SCHOOL OF BOOKMAKING is the leading institution of its kind in Germany, and probably in the world. Leipzig, the greatest book center of the world, has thus the greatest school for instruction in the art of bookmaking. The Königliche Akademie für Graphische Künste und Buchgewerbe is divided into a general preparatory school and a specialized professional school; the first is intended to lay a general foundation and to enable the student to select his special calling; the latter instructs him in this special calling. The two schools have a course of four and three years, respectively. Among the special trades taught are: Lithography, xylography, photography, photogravure, engraving, etching, ornamental drawing, chasing, printing, illuminating, bookbinding, typemaking, relief sculpture, wood carving, plastic art work, etc. All instruction is on an eminently practical basis, and in this connection the plant includes well-equipped laboratories and workshops supplementing the lecture rooms.

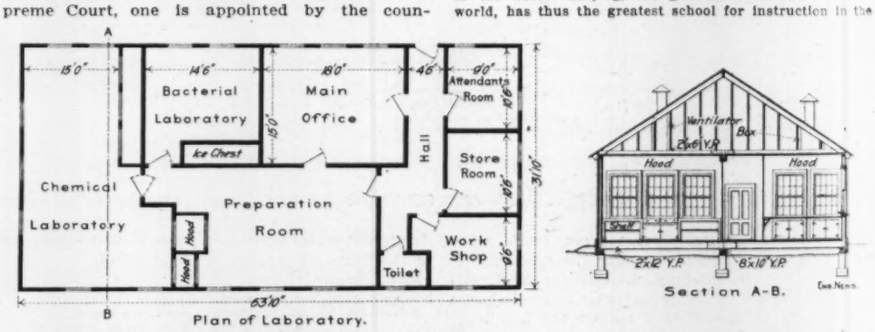

FIG. 5. PLAN AND SECTION OF LABORATORY AT THE COLUMBUS SEWAGE TESTING STATION.

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In driving tunnels through rock, there are three cost factors that can seldom be predicted with accuracy, unless the records of other tunnels in the same formation are available. These factors are: (1) The cost of handling water that may be encountered; (2) the cost of supporting the roof and sides; and (3) the cost of excavating and filling beyond the neat lines.

Many tunnel specifications are so drawn as to make the contractor assume all the risks in predicting these three items of cost. Other specifications are so drawn as to divide the risk; for example, a clause is inserted to the effect that any excavation beyond the neat lines due to unavoidable falls and breaks shall be paid for at, say, $2.50 per cu. yd.—the price named being a little less than the probable actual cost to the contractor. In this way the contractor is assured of compensation for excavation beyond the neat lines, but not enough compensation to make it an object to go beyond the neat lines, unless he has bid on unduly high price on the "packing." It is easy, however, to guard against an unbalanced bid on the "packing," so that there will be no incentive to use excessive amounts of powder in blasting.

The tendency on the part of experienced engineers has been, and will continue to be, so to draw specifications as to relieve the contractor of uncertainty as to recompense for work that he will be required to do. As indicating this tendency the following clause of a tunnel specification may be quoted:

> The contractor will be required to pump out of the upper section of the tunnel 10,000 gallons per day of 24 hours, without charge, regardless of the amount of lift. Any excess of water will be paid for at the rate per 1,000 gallons specified in the proposal.

The proposal sheet requires a bidding price per 1,000 gallons per day of 24 hours, 15-ft. lifts and less; and another bidding price for lifts of more than 15-ft. The intention of this clause is obviously to assure the contractor that he will be paid for all pumping, and the intention is certainly commendable. We would suggest, however, that since the quantity of water that may be encountered is wholly a matter of conjecture, there is one serious defect in any such specification as this; namely, the impracticability of comparing any two close bids on the tunnel work. One bidder may be a little lower in the aggregate of all specific items than another, but very much higher on the indeterminate item of pumping. The point that we wish to emphasize is that it is not, as a rule, good practice to ask for a price on any item in a bidding sheet, unless a definite quantity of that item is named in the bidding sheet. When no definite quantity can be named, as in the case of this pumping item, then it is usually best to specify that a certain price will be paid per unit of that item. In this case, for example, it would probably have been better to have named a definite price to be paid per 1,000 gallons raised 10 ft.

We note in this same tunnel specification a clause that leaves the contractor in doubt as to the payments he will receive for lining the tunnel. The clause is:

> Concrete lining will be placed throughout the tunnel as indicated by the drawings. Any excavation beyond the neat lines of the tunnel section as shown on the drawings shall be filled to the satisfaction of the engineer, and no allowance will be made therefor.

Filled with what? Broken stone packing is the common filling back of tunnel linings, but there is nothing here or elsewhere in the specification to indicate what the "filling" must be. It must simply satisfy the engineer, which is certainly too elastic a provision to be satisfactory to a contractor who wishes to bid close. But even were it clearly stated that the filling must be of concrete, or of stone "packing," it still remains uncertain how much filling the contractor must supply without recompense. Should the rock encountered prove to be of a kind that breaks beyond the line of the blast holes, then the contractor, in spite of every precaution, will find it impossible to excavate without going considerably beyond the neat lines if he uses ordinary charges of powder. If, however, he uses very small charges, and, in addition, sees to it that the drill holes terminate well within the neat lines, he will run up the cost of excavation in three ways: (1) by increased cost of drilling shallow drill holes; (2) by increased cost of powder and labor required to break the rock to sizes that can be loaded into cars; and (3) by the cost of trimming projections off the sides and roof of the tunnel. We see, therefore, that in one way or another the contractor "stands to lose," unless he makes a sufficient allowance beforehand by raising his prices above what they would be if there were no guesswork involved. On the other hand, if the specification were so drawn as to insure a fair payment for all filling or packing beyond the neat lines, the contractor would be able to bid a fair price in which the factor of guesswork would enter but little, if at all. Many tunnel specifications make just such provision for payment on work done beyond the neat lines, and all specifications should do so in the interest of ultimate economy.

Contracting has in the past been more of a "gamble" than it will be in the future, simply because engineers have so often tried to place all the burden of uncertainties upon the shoulders of contractors. The results of such action have been many, but none beneficial. Trickiness has been fostered, competition has been discouraged, and favoritism has been bred, leading to many practices essentially vicious.

What would be thought of a man who would enter a shoe store and ask for a bid on enough pairs of shoes of a given make to supply his family? Would the dealer be satisfied with a specification for the shoes, clear in every respect save one—the size of the family? Yet there is essentially but little difference between such an imaginary act and many an actual procedure. That the quantities in the bidding sheet should be definite quantities is just as essential as that the qualities in the specification be definite, and the specification that lacks definiteness, in either the one or the other, falls short of being a specification written in the interest of true ultimate economy.

There are still many bidding sheets published wherein provision is made for the insertion of prices in numerals only, instead of written prices accompanied by numerals as a check. Attention is called to this fact because within a week two instances of misplaced decimal points have come to our attention. In one case a contractor's bid read 8.00 instead of 0.08 per lb. of steel-work. Wherever a column of bidding figures must be entered opposite given materials, there is always liability of making just such an error as this one. To avoid such errors it has become customary to provide a bidding sheet on which the prices can be written out in full, but such a bidding sheet is objectionable not only because it does not offer a perfect protection against errors, but because written words are often illegible. Moreover, such a bidding sheet is bulky wherever there are a large number of items.

Practically all errors that have come to our attention where bids have been made by numerals alone, have been errors of misplaced decimals. To prevent such errors a very simple expedient will serve, which may be illustrated thus:

Quantity.	Item.	Price bid. Dols.	Cts.
500 cu. yds.	Concrete, per cu. yd	$ 6	50
1,000 lbs.	Cast iron pipe specials, per lb.	$ No	08
40 tons	Cast iron pipe, per ton	$ 31	00

The method, as above illustrated, consists in having two ruled columns headed "Dols." and "Cts." (in some cases adding a third column headed "Mills"), and in printing in bold type the word NO in the "Dols." column opposite every item that should be bid in cents. In one case where this simple method was followed, there was not an error made by bidders on a large number of contracts, where formerly errors in placing the decimal point correctly had been frequent.

When an error does occur, whether it acts to increase or to decrease the sum bid, it is obvious that the contractor should not be permitted to rectify his bid after it has been opened, nor should he be held to his erroneous bid. Perhaps it would be well to have among the instructions to bidders a paragraph to this effect:

> Bidders are cautioned against placing a dollars bid in the cents column or a cents bid in the dollars column, for any error of this character, no matter how obviously it may be an error will cause the rejection of the whole bid as being informal.

Such an injunction would tend to eliminate carelessness, and it would wipe out certain trickiness in bidding. There are a number of instances where contractors have secured contracts by being allowed to change a bid reading dollars into one reading cents, and such changes are always subject to suspicion. It is a simple matter purposely to put a cents figure in the dollars column, and then, after hearing all the bids, if it appears that the contract can be had at a good price by securing a "correction" of the bid, an unjust award may be secured. On the other hand, no risk is run of being awarded a contract at a price much below that of a competitor.

Since writing the foregoing, a report has come in to the effect that the lowest bid on a contract involving more than $100,000 was rejected because the sum total obtained by adding the numerals did not agree with the sum total of the written words. The contractor had written 40 cts. after an item on which he had intended to bid $40.

THE DIFFICULTY OF GAGING THE ABILITY OF AN ENGINEER.

"Who is the available engineer best fitted to plan and carry out our work?" This is a question that comes to the editors of every engineering journal many times in the course of a year. For every question thus put verbally or in writing there are probably a thousand asked mentally by the employer who questions himself. The difficulty in answering, in any case, arises from the fact that direct comparisons of work done by different engineers are in most cases absolutely impossible. Thus, a dam designed for conditions in a certain part of New Jersey may not be comparable with a dam designed for conditions in California. A railroad built across the Alleghanies at one place can not be directly compared with a similar line even across the same mountain range only a few miles distant. A bridge built over a river in the year 1880 can not

be compared with a bridge resting on the same abutments, but built in 1900. Conditions change not only in the space of a few miles, but in the course of a few years. Population, freight rates, capital available, rates of interest, prices of labor and materials—these, and a score of conditions besides, are in a constant state of flux. So, if we are to measure an engineer's ability by a tape of gold in which the dollar is the unit, it is obviously unfair to apply the measure to engineers who have not designed exactly similar works under precisely the same economic conditions. In the case of civil engineers, however, this is a practical impossibility in ninety-nine instances out of a hundred; the hundredth instance being usually where the design of one engineer has been gone over by another engineer, as where one railway locating party follows through the country covered previously by another party, or where the designs for a given bridge are compared with competitive designs.

The whole difficulty of gaging an engineer's ability, we see, lies in the absence of direct competition. The same difficulty, it is true, exists in estimating the merits of men in other professions, but usually not in the same degree. Moreover, the work done by men of other professions can as a rule, be judged with considerable fairness by the public, whereas it usually takes an engineer to judge fairly the work of an engineer. The architect's ability to design noble buildings, the actor's ability to portray human nature, the soldier's ability to win battles, and the lawyer's ability to win cases, are all abilities more or less measurable by men not belonging to those professions. But who, other than an engineer, can tell whether a location or a plan is excellent, mediocre, or positively blameworthy.

In selecting an engineer for any important piece of work the custom naturally is to pick a man known to have had experience on precisely similar work. But this procedure often leads to costly mistakes. There is no criterion of a man's ability afforded by the fact that he has seen, or even has been in charge of the design and construction of a great canal, for example; because, after all, the design of a great canal is little more than the summation of many small units of engineering design, and to call him a great engineer who has had to make this summation is not unlike calling a bookkeeper a great mathematician because he had added long columns of figures. There is no denying the fact that to have been in a prominent way identified with a great work has a strong tendency to stamp a mark of greatness upon an engineer, however unjustified the logic of such action may really be. For this reason we may note, in passing, that a young engineer can not afford to ignore the value of being able to point to a record of previous service on some great piece of construction work. There is, of course, the presumption that one who has secured an important position has previously had important work to do; but when we examine the actual facts how little do we find to justify the professional reverence so often shown to those who have been identified with large engineering projects. Their work, by virtue of its very magnitude, has never been measured by comparison with the work of other engineers under the same conditions, and never can be. Moreover, professional courtesy forbids criticism on the part of those best qualified to criticize; but in any case no just and full criticism can be made by anyone who has not given the same careful study to the problem as have those who have solved it.

The late A. M. Wellington, in his 'Economic Theory of Railway Location," was among the first to point out the inability to compare the work of one railway locating engineer with that of another; but, strangely enough, he appears not to have suggested what seems to us the only practical way of reducing the evil, namely, the placing of two or more separate locating parties in the same field, each under a different chief of party. Thus, with two men fairly pitted against each other, it may be safely assumed that each will be spurred to do his best in securing an economic location, and, in the end, the ablest locating engineer will become known as such to the chief engineer.

It would seem that in many other classes of engineering work, competitive solutions of the same problem might be secured, if at an increased cost for engineering, certainly at a decreased cost for the structure. For example, instead of adopting the first design submitted for the abutments and piers of a bridge, it might pay well to let another subordinate engineer in the same office present alternative plans and specifications for the same work. In such cases the difficulty lies in fairly judging the economic merits of the competitive plans. It goes without saying that no one but an engineer should attempt to be the judge.

A board or commission of men who are not engineers is often called upon to judge the merits of competitive plans, as, for example, in awarding a contract for highway bridges designed by the engineers of the competing bridge companies. But the awards of such boards are never satisfactory. Incidentally, we may add, it would be exceedingly difficult for any one to decide justly as to the respective merits of competitive designs submitted by two or more engineers who are themselves recognized authorities and specialists in their fields. We shall not undertake to discuss this phase of the subject at present, but will confine the discussion to competitive work by men working under a chief engineer who is, presumably, a fair judge in matters pertaining to engineering.

One of the most important functions of a chief engineer is passing upon plans submitted by his subordinates, and one of the purposes of our argument is to show that this function should be exercised to a greater degree than it usually is. But many chief engineers, acting under the desire to keep down engineering expenses, permit one man to rush through a survey and blue-print his half-thought-out designs, without any fear of being confronted with comparative plans to test their worth.

Competition not only brings to the front the best men available, but it makes better men of them. This is strikingly shown in business, and in professional work as well wherever competition has a chance to operate. The contractor is able to do work at a less cost than an engineer can do the same work by day labor, not only because the contractor's profits—his salary—are dependent upon the exercise of his wits and his energy, but because he is usually a picked man. In the course of time the least efficient among contractors are weeded out by competition. There is, unfortunately, no such severe weeding out process going on among engineers; although, it is true, a certain process of selection does exist. With the more general employment of civil engineers by contracting firms, competition will act more effectively than ever, for there will result, inevitably, clearer and more thorough specifications; and, as a consequence, success will be assured for men who have brains to use and who use them in devising economical methods of doing work, rather than in devising ways and means for "getting the better" of the engineer.

The selecting of an efficient engineer by a contracting firm is made difficult by the fact that there is little to be used as a guide in forming judgment of an applicant's real ability. It is again the same old story of men without standards of comparison. But, in the case of the contractor who has an engineer for a superintendent, there is at least the satisfaction of knowing whether the choice has been wise or unwise, for the ledger is a witness that will not be biased in its testimony. The danger to the contractor lies in being financially crippled while thus testing a new superintendent.

It must be apparent that years of experience, like the degree of C. E., mean little as guides in estimating the true worth of an engineer further than as they show him to have been fortunate in having had opportunities to learn. Viewed in this light a long experience on a single class of work may actually be regarded as of questionable value, just as one would regard eight years spent in taking a four-year college course. One engineer at thirty-five may have had a broader experience than another at fifty, but in either case the experience indicates in itself nothing more than that the man has been at school. His true fitness can be ascertained only by contests of wits, and these contests must not be upon different problems but upon the same problems. This means that if we are to make a hundred cents buy the most structural work, we must pay more than three hundred cents for engineering. Yet, we dare to say, so strong is the desire to make record for economy in engineering expenses that on railways and on public works, vast sums annually wasted in designs that are by no means the most economic attainable. This same penny-wise-ness is seen also where low salaried engineers are selected by contractors, and other men penny-wise-ness, who fail to consider that if the engineer is an able man he will sooner or later resign. If he is not an able man he will waste many times the amount of his salary.

The ideal method of selecting an engineer would be to place him in direct competition with another engineer on some class of work where results can be measured. The work need not be of great magnitude, but it should be of a kind to call for the same qualities and same general training as will be needed on subsequent problems. An ingenious, alert, yet careful engineer will demonstrate these qualities even in the smallest engineering problems assigned to him. It is safe to assume that such a man will prove himself capable of solving any great problem in an economic manner; while it is not safe to assume that because a man has solved great and similar problems he has solved them well.

LETTERS TO THE EDITOR.

The Highest Mountain in the United States.

Sir: Under the picture of Mt. Rainier published in your issue of Sept. 29 appears the statement that this is the "highest mountain in the United States, altitude, 14,500 ft." According to a table prepared by the U. S. Geological Survey and published in the "World Almanac" for 1902 and in "Gentistoria," a volume of statistics published in Washington, D. C., Mt. McKinley, in Alaska, has an altitude of 20,464 ft. and Mt. Whitney, in California, an altitude of 14,898 ft. The altitude of Mt. Rainier is given by the same authority as 14,500 ft. It appears, however, that it is not the highest in the United States.

Yours truly,

Charles W. Comstock.

Denver, Colo., Oct. 6, 1904.

The Failure of Cast-Iron Pipes Supported on Saddle Piling.

Sir: In your issue of Sept 22, under the heading "Some Recent Sewer Specifications," a clause calling for the use of saddle piling for the support of sewer pipe is given. This recalls a failure of a somewhat similar piece of work which occurred a few years ago on a prominent Western railway. The railway was doing some change of line work in connection with double-tracking, and was using cast-iron pipe, up to diameters of 6 ft., for culverts. The engineer in charge decided that the bottom at one location was not firm enough to support the pipe unaided; he therefore had rows of sheet piling driven across the trench, and then rounded out to receive the pipe. He provided only one saddle for each 12 ft. length of pipe, and located that just back of the flange, the remainder of the pipe lying on the bed of the trench. The result was that several joints were broken at the support as soon as the weight of the fill came upon the pipe, showing that saddle piling for pipe lines must be placed with the same care that is necessary in other foundation work.

Yours truly,

C.

Lake City, Oct. 7, 1904.

A Perch of Stone Is Only 16½ Cu. Ft. in Many Localities.

Sir: A perch of stone is defined in books on arithmetic as being a volume of masonry 1 rod long (16½ ft.), 18 ins. wide and 12 ins. high, which is equivalent to 24¾ cu. ft. In the course of his work in California, Idaho, Washington and Montana, the writer has never found a mason who counted a perch as being more than 16½ cu. ft.

The writer once estimated a piece of mason work and let a contract for the labor, the company furnishing the stone. When the work was done the masons put in a bill for 600 perches of stone, whereas the estimate was for 400 perches. Under the arbitration clause the matter was adjusted. The company furnished a man, the masons another and the two selected a third. Over 50 masons, carpenters, contractors and men who employed masons frequently testified that "no matter what the books say" a perch was one rod long and a foot square. It was taken to court and the judge decided that local custom governs.

Since then the writer has made it a rule to specify cubic feet instead of perches. He has, however, inquired in

every place about the perch and so far has failed to find a working mason who works to a perch larger than 16½ cu. ft.

Yours truly,

Civil Engineer.

Chicago, Ill., Oct. 6, 1904.

Concrete vs. Stone Masonry.

Sir: The report of the tenth annual convention of the Association of Railway Superintendents of Bridges and Buildings, held in St. Louis, Mo., Oct. 16, 17 and 18, 1900, contains a discussion of the following question:

Is concrete a Suitable and Economical Material for Bridge Piers, Abutments and Railway Culverts and Arches?

As this discussion took place just at the beginning of the present concrete era, I believe it would be interesting to the profession to re-open the question in the light of later experience and the conditions of these later days.

The prevailing craze to use concrete to the exclusion of stone masonry, even where suitable stone is obtainable, has always appeared to me entirely unwarranted.

Concrete in railroad structures, especially in northern latitudes where the same are exposed to great variations of temperatures, alternate freezing and thawing, contracting and expanding, must be regarded as entirely experimental. Experiments with concrete ties, re-enforced and otherwise, have so far proven failures. Vibration and exposure soon terminate their life. They become tired like any other metal subject to the same conditions and then fail. May not similar results be expected in larger structures?

It has always appeared to me that the greatest advantage in concrete work is to the contractor. He is able to do the greater part of the work with unskilled labor, and it is yet commonly supposed that he can erect it quicker than stone masonry, although the loss of much valuable time on account of the delivered cement not coming up to the specification is a common experience.

As regards prices there is little if any difference between those for good cement or second class masonry, near cement and stone centers; prices ranging from $7.50-$9.00 per cubic yard, this includes forms for concrete. In this connection it is curious to note to what extremes the concrete madness has gone, when recently an engineer declined a contractor's offer to lay second-class masonry instead of the concrete called for by the specifications, although the price was to be the same in each case and the stone was perfectly satisfactory.

Although it has come within my experience to place many thousands of yards of concrete, still I have always remained an advocate of stone masonry, principally for aesthetic reasons and because the use of concrete above ground has been too recent, too limited, to warrant its present indiscriminate use.

Since the date of the above-mentioned report great strides have been made in pneumatic tools; hoisting apparatus and quarry methods have been greatly improved. The hardest of stones can be worked by pneumatic tools in an incredible short time; this saving in time is so great that it should and will cause entire new conditions as regards masonry prices and contracts.

In view of this would it not be well to retrace our steps somewhat, encourage the use of stone masonry, and leave concrete for those places where the conditions are such as to make its use unavoidable?

Respectfully yours,

J. W. Stadly,
Mem. Can. Soc. C. E.

North Bay, Ont., Sept. 30, 1904.

A Note on the Crown Thickness of Masonry Arches.

Sir: In your issue of Sept. 15, 1904, Mr. Emile Low, M. Am. Soc. C. E., gives a new formula for the depth of arch ring at the crown for masonry arches. As he compares the results obtained from the formula with the crown depths of many existing highway and railway bridges, I presume the formula is intended to apply to either highway or railway stone arch bridges. If so, the formula is open to criticism from this cause alone. Many formulas have been proposed by various engineers for crown depth, differing widely from each other in results, all being empirically obtained by a consideration of the successful practice of the past, mainly from highway bridges. If any one of these formulas is correct for a highway bridge, then it seems to me to stand to reason that it is incorrect for a railroad bridge, carrying the enormous locomotive and train loads of to-day.

The formulas of a number of authors are given in my "Theory of Voussoir Arches," 2d. ed., pp. 145-149. The results, for a rise of one-fifth the span, are given in the adjoining diagram. The curve given by Mr. Low's formula is added for Rise ÷ Span = 1-5, and surcharge H = 0.

The French authors increase the radial length of joint in going from the crown to the abutment, often making it vary as the secant of the inclination of the joint to the vertical. The depth of joint refers to stone of "medium resistance," not so hard as granite, say sandstone or best brick.

The dotted line in the adjoined diagram gives the results of a theoretical investigation on spans varying from 12.5 to 150 ft. for an arch ring of uniform section. The theory for the solid elastic arch was used, the noted Prussian experiments indicating that this theory pertains to the voussoir arch within proper limits. The live load used was about equivalent to Cooper's Extra Heavy A locomotive (1891 specifications), and this was placed in the most hurtful position, causing the greatest departure of the center of pressure from the center of the joint considered. The arch ring of uniform section was so designed that the centers of pressure on the joints kept everywhere within the middle third of the arch ring as the live load passed over the bridge, though at one joint (at least) the center of pressure reached the outer limit for some position of the lead. The computation and construction were made by two independent methods which checked perfectly.

Granting their correctness, it is seen that the depth of key is much greater than is given by any author except Scheffler for spans of 40 to 90 ft., and Dejardin for spans of 100 ft. and upwards. Which of these lines represents the best practice for the heavy rolling loads of to-day? Of course, the theory is inapplicable if the arch stones do not fit accurately. The depth then should undoubtedly be increased in place of the reverse.

Again, suppose the loads are transmitted to the arch ring by vertical columns, as has been done; the theory is then evidently applicable and it would be very unwise not to use it.

If the backing is of earth, as usual, the loads may not be transmitted vertically and the backing may resist spreading of the arch ring appreciably. In place of discarding the theory, is it not better to apply it as approximately correct and regard the backing as neutralizing the *dynamic* effect of the moving load? If, however, the backing is solid masonry or concrete, or even if it is composed of parallel longitudinal walls, it is admitted that the theory used above is inapplicable and empiricism may be resorted to.

The middle third limit may be objected to (where the theory is applicable) as being too narrow, but when it is considered that the effects of temperature, which are quite appreciable, have been neglected, it seems a reasonable limit and may be looked upon in the light of introducing a factor of safety.

In conclusion: (1) the writer thinks that empirical formulas for depth of key should be different for highway and railroad bridges; (2) such formulas serve a useful end, but for earth filling and especially for isolated columns to transmit the weight of roadway and rolling loads to the arch ring the theory of the solid arch should be applied; (3) except for small spans, the section of the arch should increase from the crown to the springing, in which case theory calls for a smaller depth of key than for the arch of constant section.

There seems no valid reason why concrete or steel-concrete arches, with earth filling, should be carefully designed by aid of the theory of the solid arch (the graphical treatment is a practicable one) and the voussoir arch designed by rule of thumb only.

The design of some recent bridges would seem to indicate that constructors have realized that the heavy rolling loads of to-day should be provided for as the backing has been made much more rigid by the employment of concrete.

A word may be added as to the allowance to be made for the height of surcharge above the crown. The French authors add .02 H (in feet) to the crown depth, the surcharge having been reduced to the density of the masonry, and the reduced height in feet being denoted by H. Mr. Low places the term involving H under the square-root sign. I am not prepared with any figures to criticise either plan, but from general considerations it would seem that a certain amount of surcharge would be conducive to increased stability, both in deadening shocks due to rolling loads and in increasing the active thrust or passive resistance of the earth and thus tending to prevent the arch from spreading or moving outwards at the haunches. If this is true, then the depth of key need not be increased until H is such that the unit stress at the crown has reached the limit regarded as safe. For greater values of H, strength as well as stability requires an increase of depth of key as H increases.

Wm. Cain.

Chapel Hill, N. C., Sept. 26, 1904.

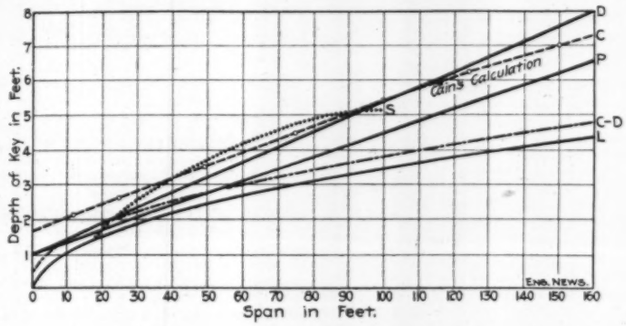

DIAGRAM OF VARIOUS FORMULAS FOR CROWN-THICKNESS OF MASONRY ARCHES, AND RESULTS OF CALCULATIONS FROM ELASTIC THEORY BY PROF. WM. CAIN.

For Rise = 1/5 Span.

Note:

D = Dejardin's formula.
S = Scheffler's formula.
P = Perronet's formula.
C-D = Croizette-Desnoyers formula.
L = Low's formula.
T = Trautwine's formula (not shown, very near line L.)
C = Plot of Cain's Calculations from Elastic Theory.

American Practice in Stream Measurement.

Sir: In an article on "Recent Russian Studies of Flow in Rivers" in the Engineering News of Sept. 1, it is set down:

> In gaging the flow of streams it is usual to take plane cross-sections normal to the trend of the shores, it being assumed that the currents are parallel to one another and to the shores.

While this may represent European custom, it is not true of the best American practice. It is not proper to orient a section for hydraulic measurements by the trend of the shores, but to lay it out normal to the predominant current threads; and it is usual to introduce a direction coefficient for the horizontal deviation from the normal of the current lines at each station, by which the observed velocities are reduced to their normal components.

It is not, however, usual to take into account any deviation of the current threads in the vertical; as each procession of particles is taken as traveling a path trending so nearly horizontal that no significant error will enter by neglecting its inclination. Safety in this respect lies in a well selected hydraulic section, in which the water runs still, swift and deep, with a straight course and a plane bottom. It is doubtful if the best results in river measurement can be obtained by any multiplication of corrections, where the section does not approach these conditions.

By using hydraulic sections evidently not well adapted to precise measurement, and by orienting the sections by the shore lines instead of by the main current lines, the corrections for current deviation as determined by Mr. Leliavsky are very large, varying from 1.75 to 10.32%. (See Table C, Eng. News, Sept. 1.) The detail of the data from which these values were derived would be of much interest, the speed of the water, its depth, its path; the relative importance in the volume of flow of those parts of the stream showing excessive deflection; weighted mean values of the deflection instead of maximum values; the bearings of the predominant current lines at each station of the river traverse, and the bearing of the hydraulic section; but most particularly a separation of the values of the corrections for deviation in the vertical from those of deviation in the horizontal.

It is hardly credible that prior to Mr. Leliavsky's experiments continental engineers engaged in serious river measurement would lay out a section across a stream by so faulty a criterion as the trend of the shores, and neglect to apply corrections for the oblique intersection of this plane by the current threads. It is certain that this method did not prevail in the United States. The Haskell-Ritchie direction current meter, designed to measure these deflections in the horizontal, has long been in use by American river gagers.

The most notable river hydraulics of recent years is the work of the Lake Survey* under the Corps of Engineers

*United States Lake Survey, No. 33 Campau Building, Detroit, Michigan. Major W. L. Fisk, Corps of Engineers, U. S. Army, in charge.

U. S. Army. The measurements of the discharge of the rivers which bear the outflow of the Great Lakes were preliminary to a project to maintain fixed lake surface levels by controlling works constructed in the outlets. So vast a project warranted elaborate hydraulic investigations, including measurements of the flow to the limit of attainable accuracy.

The detail of methods and results of the recent Lake Survey work on the St. Mary's, St. Clair, Detroit, Niagara and St. Lawrence Rivers may be found in the Reports of the Chief of Engineers, U. S. Army, for 1900, 1901, 1902 and 1903. The writer was in immediate charge of the measurements of the Niagara and St. Lawrence Rivers.

In this work a precision as great as 1% was looked for; and the various elements that entered into the problem, instrumental constants, cross-sectional areas, gage heights, index velocities and velocity coefficients, were determined with great care.

The importance of good hydraulic sections was fully appreciated, and they were laid out with regard to the current lines. On the St. Lawrence River, in locating the Three Points Section, the correction for horizontal deviation was reduced to a minimum by the following procedure: A trial section was first thrown across the river, oriented by the apparent current trend, soundings taken, and the velocity and direction of the current measured on stations 100 ft. apart. From this preliminary data the permanent section was projected, being swung enough in azimuth, from the line of the trial section to make it normal to the predominant current threads. In this azimuth adjustment of the hydraulic section each station is regarded as important in proportion to the volume of flow in the area which it controls, and a weight is given to each station representing its percentage of the total river flow.

The shore-end stations, where the maximum horizontal deviations occur, are of little importance, as the water is shallow, and the speed slow, and hence the volume of flow is trivial; it is the mid-stream stations, where the river is flowing swift and deep, that control. This is shown by the following tabulation:

Station Elements, Three Points Section, St. Lawrence River.

Number of station. a	Width, ft. b	Depth, ft. c	Velocity at 4-10 depth in sec.-ft. d	Percentage of discharge. e	Horizontal deviation of sub-surface current. f
1	86+	4.7	1.71	0.3	17° South
2	100	7.2	3.19	1.1	18° "
3	100	21.2	4.33	3.7	14° "
4	100	23.8	4.46	4.0	9° "
5	100	28.4	4.79	5.3	7° "
6	100	36.4	4.93	6.9	5° "
7	100	42.4	5.19	8.9	5° "
8	100	47.6	5.11	10.8	1° "
9	100	56.1	5.26	12.4	2° North
10	100	55.1	5.20	11.8	4° "
11	100	52.7	4.81	10.0	5° "
12	100	45.3	4.52	8.2	8° "
13	100	36.2	4.22	6.1	5° "
14	100	26.7	4.02	4.5	6° "
15	100	18.3	4.14	3.1	8° "
16	100	9.1	4.07	1.8	8° "
17	100+	5.3	3.83	1.1	10° "

The river is flowing eastward, and Station 1 is on the north side of the river. The angles are measured north and south of a normal to the section.

The convergence of the current lines towards the river center is well marked, with maximum angles of 18° South and 10° North, with an angular difference in the extreme current threads of 28°. But the shores are converging also, and the water is accelerating for the passage of the narrow Three Points gut.

The angles of deviation are of considerable value here, yet if neglected the error in the discharge would be but 0.6%, and this direction correction of less than 1% is small because the hydraulic section is a good one, and because it is oriented, not normal to the shores, but normal to the predominant current lines.

In deriving formulas for velocity coefficients (see page 5.344 of Report of Chief of Engineers for 1900) the writer includes the horizontal direction coefficient, but takes no account of any inclination of the current threads in the vertical. Mr. Leliavsky's later and more extensive work on the River Desna, as shown in Table B. (Eng. News, Sept. 1), is entirely confirmatory of the position of the writer that a correction for deviation in the vertical is practically negligible. Thus, in 77 sections the mean maximum angle of inclination was 7°; it is fair to presume that the weighted mean angle would be less than half the maximum. But if it be taken as half, 3½°, the correction would be but 0.2%; and in well chosen sections probably not more than half this amount.

It is difficult to believe that in the bottom third of a river the current lines are trending downward at an angle something like 7°, because in this case the water particles must reach bottom and rebound, trending upward again, resulting in sinuous paths or cycles of endless complexity. It is easier to believe that close to the river bottom the higher velocity on the upper side of the vane than on the lower side makes the vane indications unreliable.

Whatever the truth of this may be, it is well known to river gagers that the layer of water next to the river floor, the bottom tenth, is in a condition of excitement that renders velocity measurements there somewhat indeterminate. Why not direction measurements also?

In the end a tabulation of maximum deflections, like a rogues gallery, is misleading, for the abnormal parts of a good hydraulic section, where the current lines are erratic, carry but a small proportion of the flow. In the St. Lawrence River section cited, the bottom tenth bears but 6% of the discharge, and a full quarter of the river width in the four shore-end stations shows but 4.3%. Even so large an error as 10% in the measurement of these doubtful parts of the stream would mean only 1% error in the total river discharge.

Francis C. Shenehon, M. Am. Soc. C. E.

Leamington, Ont., Sept. 19, 1904.

Notes and Queries.

A typographical error in the report of the meeting of the Society for the Promotion of Engineering Education, in our issue of Sept. 8, gave the increase in membership during the year as 150%. The correct figures are 15%.

In reporting the discussion on the papers read before Section B of the International Engineering Congress the name of Mr. E. B. Weston, of Providence, R. I., was inadvertently substituted for that of Mr. Robert Spurr Weston, of Boston.

A TEST OF A NEW FIRE HYDRANT was made on Oct. 17 at the yard of the Department of Water Supply, Gas and Electricity, New York City. The hydrant barrel is surrounded by an air chamber, connected, at its base, with the water main by means of small openings. The aim of the air chamber is to reduce water hammer, prevent freezing and aid in the speedy draining of the hydrant when the water is shut off. The hydrant tested was simply one of the new type used by the department named, adapted to include the features already mentioned. In the tests made the pressures on the air chamber and at the hydrant nozzle were noted and also the time required to drain the hydrant. It was found that the pressures on the two gages were about the same and that the hydrant drained quickly. A further test is proposed, using a mercury U-gage connected to the hydrant nozzle and the air chamber. It is also proposed to place a meter on the supply main and to take cards showing the vibration due to opening and closing the compression valve controlling the supply to the hydrant. The new features of the hydrant were designed by Mr. Horace See, and were suggested to him in connection with stoppages and water hammer in hydraulic ash ejectors used on shipboard. Mr. Geo. W. Birdsall is Acting Chief Engineer of the Department of Water Supply, Gas and Electricity.

A FEDERAL "GENERAL SLOCUM" INQUIRY has just been completed by a special commission appointed by the President and the Department of Commerce and Labor, for the purpose of investigating the burning and sinking of the excursion steamer "General Slocum" in New York Harbor on June 15, 1904. The report of this commission, made public in abstract, primarily charges the master and the pilot of the vessel with blame for poor judgment in handling the vessel after the fire began. The crew is charged with total inefficiency, which, however, is largely to be blamed on the master of the vessel, because no fire drills were held. The fire-fighting equipment of the vessel is characterized as absolutely inadequate, for which the owners of the vessel mainly are blamed. Finally, the Steamboat Inspection Service of District No. 2 is charged with inefficiency and neglect of duty, this applying more directly to the officers in charge: R. S. Rodie, Supervising Inspector, and J. A. Dumont and T. H. Barrett, Local Inspectors. These three men have, in consequence, been ordered by President Roosevelt to be removed from office.

Besides considering the question of direct responsibility for the "General Slocum" accident, the commission considers at length the general conditions brought to attention by that accident, and recommends steps for improving these conditions. Many specific changes in the regulations for passenger vessels are suggested, and a general reorganization of the inspection service is advised. The commission urges that a special board of experts be appointed for considering fully the subject of construction of steamboats, including ocean steamers, the subject of maximum passenger allowance, and the entire subject of steamboat inspection law. It is also urged that the Inspection Service be given more power, to enable it to enforce the statutes and regulations more effectively. Besides many general and specific suggestions about the statutes and regulations, the commission says: "Many details should be confined to the regulations instead of being made statutes."

In a published reply to this report R. S. Rodie, the Supervising Inspector of the New York District, has stated that at the convention of the Board of Supervising Inspectors of Steamboats, early in 1903, the subject of the law and the regulations was thoroughly gone over, and an extended series of recommendations for amendments was reported. These recommendations, which covered almost completely the conclusions drawn by the recent commission, besides correcting many other serious evils, failed of approval by the then Secretary of the Department of Commerce and Labor, Mr. Cortelyou, and consequently did not go into effect.

A SLAG-CAR ACCIDENT at the Wharton Furnace, near Morristown, N. J., caused fatal injuries to four men. A ladle full of molten slag was set on a flat car to be hauled to the slag dump. On the way a car in the train was derailed, and the shock upset the ladle, part of whose contents struck the engines, burning the four men in the cab.

THE 16,000-TON BATTLESHIP "CONNECTICUT" was successfully launched at the New York Navy Yard on Sept. 29. The vessel is to be a sister-ship of the "Louisiana," whose launch at Newport News, Va., was noted in these columns of Sept. 1, 1904. The "Connecticut" is the first war-vessel built by the U. S. Government since many years ago. The construction of the vessel at the New York Navy Yard is intended to give an indication of the relative facility and economy of ship-building in private yards and in government yards.

AUTOMATIC LAUNCHING characterized the ceremony of christening and launching the 15,000-ton battleship "Nebraska" at the shipyard of the Moran Brothers Co., at Seattle, Wash., on Oct. 7. The vessel tore loose from the tie-piece while the last shores were being knocked out, about ten minutes before the time set for launching. The launch went off without accident. The vessel is 441 ft. 3 ins. long over all; 76 ft. 2½ ins. in extreme breadth, and draws 23 ft. 9 ins. The engines are to be of 19,000 I. HP., to give the vessel a speed of 19 knots. The main battery is to comprise four 12-in., eight 8-in. and twelve 6-in. guns.

ELECTRIC AND HOT-WATER HEATING SYSTEMS are reported to have proved unsatisfactory on the lines of the Public Service Corporation, which operates the trolley lines in nearly all of northern New Jersey. Stoves will be installed for use during the present winter, according to a report of the "Electrical Review" of New York.

TESTS OF ELECTRIC CAR BRAKING SYSTEMS are being carried out by the Electric Railway Testing Commission at the St. Louis Exposition. The St. Louis Transit Co. has the largest equipment in service of the compressed air storage braking system, made by the Westinghouse Traction Brake Co. In this compressed air brake system the compressed air is carried in a reservoir on the car which is replenished at various stations along the car lines. Each of these stations is equipped with two Ingersoll-Sergeant air compressors, which are driven by electric motors taking current from the trolley circuit. The Electrical Test Commission has made a test of a compressor station and also of the apparatus on an electric car in regular service. A test was also carried out on the same car with an automatic air compressor made by the National Electric Co., mounted on the car. Prof. Henry E. Norris, of Cornell University, is in charge of the work of the Electrical Test Commission.

THE ALASKA CABLE NETWORK was completed on Oct. 6, when the cable from Sitka, in extreme Southern Alaska, northwest to Valdez, on the south coast of Alaska, was opened by Acting Governor Distin. The territory of Alaska now has 46 cable stations all interconnected and connected with Seattle, by exclusively American cable lines.

THE THREE-PHASE EQUIPMENT OF THE VALTELLINA railway, in northern Italy, which was put in by Ganz & Co., of Budapest (Hungary), about two years ago, was formally accepted by the railway company in July last. This was several months short of the two-year term during which the contractors were to operate the road and demonstrate the success of the equipment. This line is equipped with high-tension trolley, three-phase, and the cars are operated by three-phase induction motors. It is now reported that trials are to be run on this line with the Finzi single-phase system, which employs series alternating-current motors similar to the Westinghouse system in this country. It is proposed, according to "The Electrician," of London, to use 3,000 volts in the trolley wire, transforming down to a variable voltage—200 to 400 volts—on the motors. The starting and control of the motors is to be accomplished by varying the voltage in the transformer without rheostatic resistances.

These tests will be for the purpose of giving a comparison between the Finzi single-phase system and the three-phase induction-motor system. That the latter is considered a practical success is evidenced by the early acceptance of the installation and by the fact that only recently three 1,600-HP. electric locomotives were added to the equipment of the Valtellina line (a branch of the Southern Italy Railway Co.).

THE EXPLOSIVES CONSUMED IN THE TRANSVAAL gold mines during the month of July were, in round numbers, 848,000 lbs. of gelatin, 252,000 lbs. of gelignite and 671,000 electric detonators. In the same month 790,300 tons of gold ore were hoisted, indicating a consumption of about 1¼ lbs. of explosive per ton of ore. There were 1,684 rock drills in use, of which only 172 were non-productive, or about 10% of the total number.